THE Petroleum Engineer

Tulsa, Oklahoma November, 1931

E. B. REESER

President, Barnsdall Corporation, now serving his third term as President of the American Petroleum Institute.

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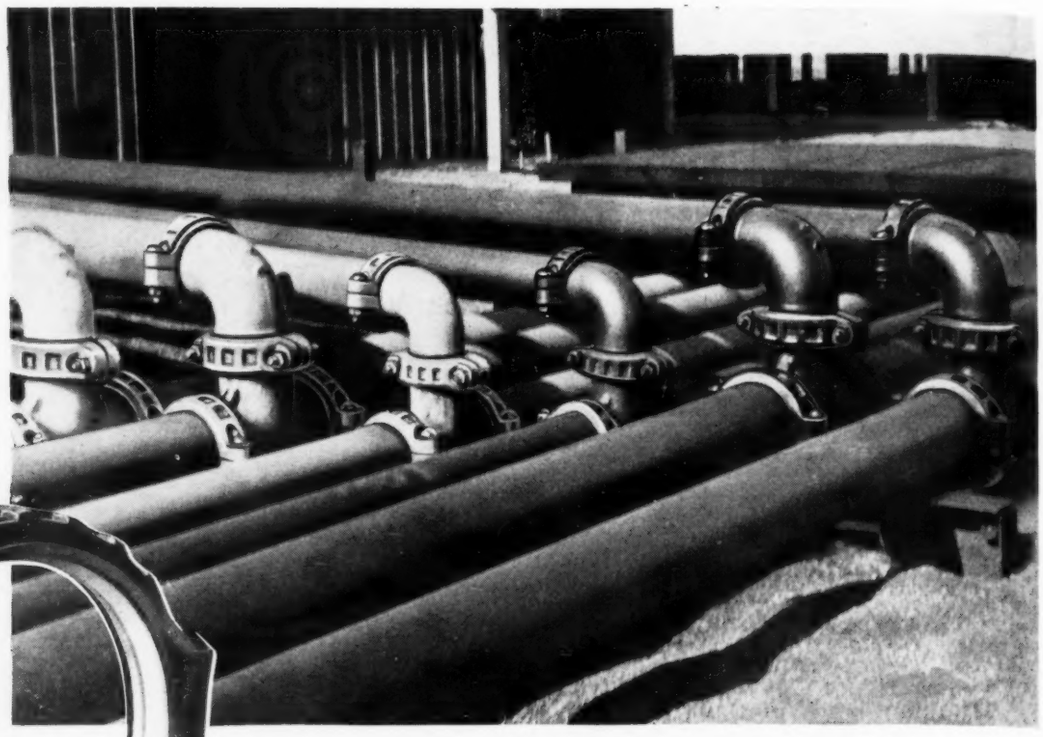

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The Engineering Magazine of the Oil and Gas Industry

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Volume 3 | NOVEMBER, 1931 | Number 2

This issue contains

	Page
The Month's Highlights in Oildom — By J. L. Dwyer	13
Paraffin Troubles in East Texas — By K. C. Sclater	14
Refinery Engineering Progress Shown in East Texas Plant — By F. R. Staley	17
Turbine Pump Operates Closed Diesel Engine Cooling System — By J. H. Dameron	19
Practical Methods for Making Individual Production Tests for Stripper Wells — By Frank B. Neptune	22
Sucker Rods—Why They Break — By C. G. zur Horst and Blaine B. Wescott	26
Floor Tubes in Cracking Units — By George Pfau and C. A. Barrere	32
Despite Obstacles World's Longest Casing String Safely Landed — By Warren L. Baker	50
Fifteen-Year-Old Machine Shop Proves Economical Investment	55
Recent Developments in Automatic Rectifier Control — By Louis H. Brendel and E. H. Hammond	57
The Selection and Maintenance of Control Equipment for Squirrel Cage Industrial Motors — By T. D. Williamson	65
The Fractionation of Heavy Oils — By W. L. Nelson and Dr. Mott Souders, Jr.	98
Large Gathering System for Hugoton Gas Field	104
Unusual Drilling Conditions in New Colorado Pool	107
The Use of Kick-Off Collars — By Donald R. Baker	115
Adaptability of Hard Surfacing Materials to Oil Field Diamond Drilling — By Edmund B. Stiles	118
Use of Air Chamber Reduces Pumping Wells' Down Time	122
Automatic Temperature Controllers — By W. C. Begeebing	124

REGULAR DEPARTMENTS

Pictorial Petroleum	Pages 89 to 96, inclusive
Latest Activities in the Oil Fields—	Pages 36, 38, 39, and 40
Progress of Major Pipe Line Work—	Pages 42 and 44
Pipe Lines Under Construction and Contemplated	47
The Month's Activities in Refining	48
Running Tour With Men in the Industry—	Pages 83 and 84
New Petroleum Equipment—	Pages 72, 74, 76, 78, and 80
Laugh With Barney	86
Strange But True Happenings in the Petroleum Industry	112
New Patents of the Industry	126

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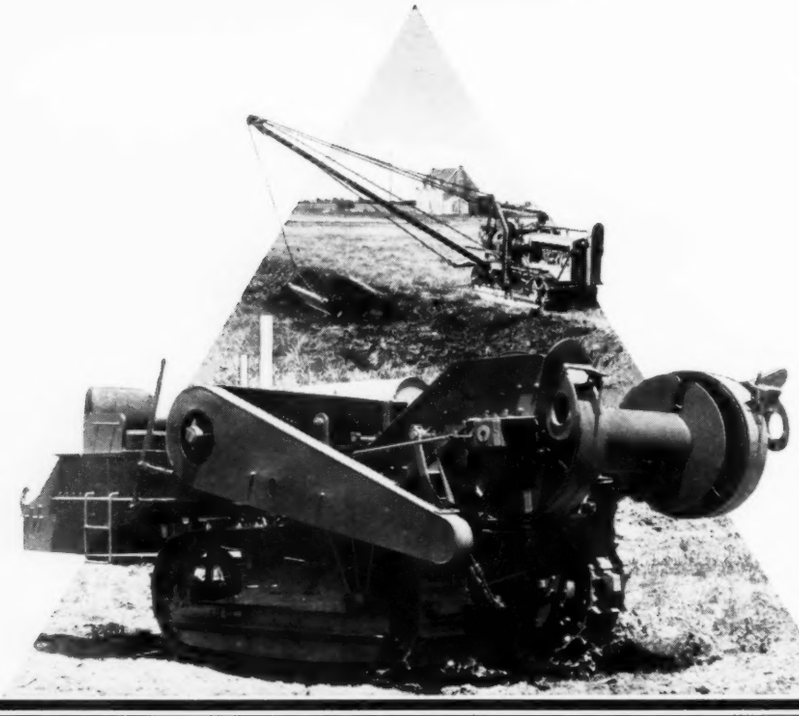

Top View shows Cardwell Backfiller Model 20, mounted on a No. 20 Caterpillar.

Lower View shows Cardwell Model St. 60 Oil Field Winch mounted on a Caterpillar 60.

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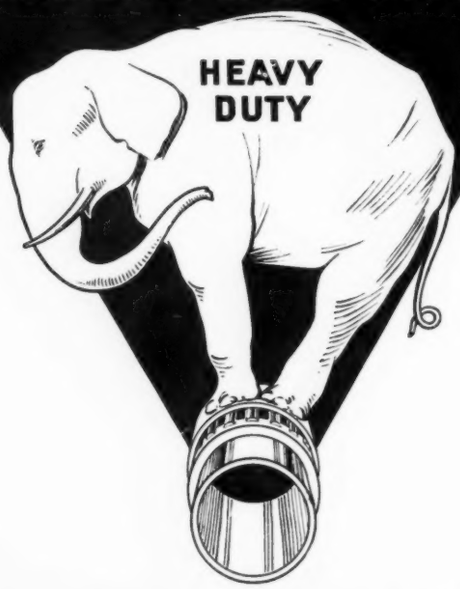

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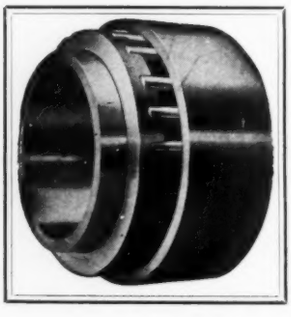

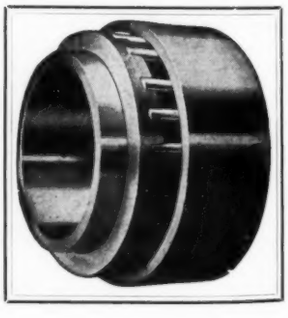

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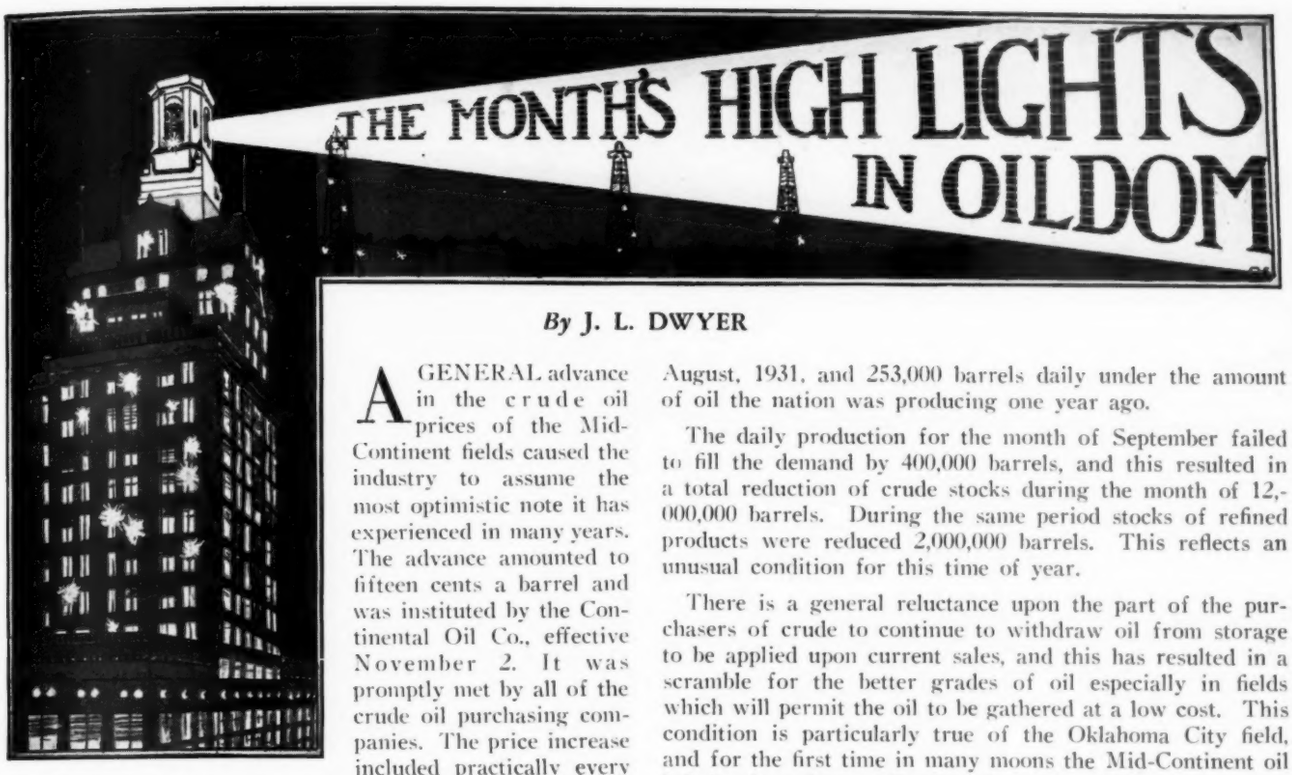


By **J. L. DWYER**

A GENERAL advance in the crude oil prices of the Mid-Continent fields caused the industry to assume the most optimistic note it has experienced in many years. The advance amounted to fifteen cents a barrel and was instituted by the Continental Oil Co., effective November 2. It was promptly met by all of the crude oil purchasing companies. The price increase included practically every field in the Mid-Continent, and it is believed that higher prices for California oils may be announced during the month of November.

Unquestionably the stabilization of crude oil production has been responsible for the sweeping price advance. With East Texas being held close to 400,000 barrels daily, the Oklahoma fields being held under 450,000 barrels daily, and the daily crude output of California being maintained under 500,000, an extremely healthy market has resulted.

The figures of the United States Bureau of Mines show that for the month of September the daily average crude oil production of the nation was 2,121,000 barrels, the lowest figure registered in almost five years. This production is 86,000 barrels less than the production for the month of August, 1931, and 253,000 barrels daily under the amount of oil the nation was producing one year ago.

The daily production for the month of September failed to fill the demand by 400,000 barrels, and this resulted in a total reduction of crude stocks during the month of 12,000,000 barrels. During the same period stocks of refined products were reduced 2,000,000 barrels. This reflects an unusual condition for this time of year.

There is a general reluctance upon the part of the purchasers of crude to continue to withdraw oil from storage to be applied upon current sales, and this has resulted in a scramble for the better grades of oil especially in fields which will permit the oil to be gathered at a low cost. This condition is particularly true of the Oklahoma City field, and for the first time in many moons the Mid-Continent oil belt is witnessing a sellers' market rather than a buyers'.

If the present rate of production throughout the nation be maintained during the winter months, a continuation of the improved situation may be expected.

The average inventories of the companies holding important stocks of crude oil at the close of the year 1930 were based upon dollar crude, and it would not be surprising to many students if the close of the current year would reveal a price structure which will approximate this figure.

During the past two years many refineries have paid as little attention as possible to replacement problems, permitting their equipment to deteriorate. This condition must be remedied, and during the coming year much refinery work should be done.

Production and Refining Figures Furnished by the American Petroleum Institute

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks, Week Ending October 28, 1931

(Figures in Barrels of 42 Gallons)

DISTRICT	Per Cent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Per Cent Operated of Total Capacity Reporting	Gasoline Stocks	Gas and Fuel Oil Stocks
East Coast	100.0	464,300	73.3	4,079,000	10,405,000
Appalachian	91.8	109,400	79.6	1,330,000	1,641,000
Ind., Ill., Ky.	98.9	339,100	78.6	3,337,000	5,449,000
Okla., Kan., Mo.	89.6	242,900	55.8	2,868,000	5,057,000
Texas	91.3	558,700	73.0	5,634,000	11,348,000
Louisiana - Arkansas	98.9	154,100	63.9	711,000	3,742,000
Rocky Mountain	89.4	39,000	27.1	1,284,000	831,000
California	97.1	491,000	55.4	*11,975,000	96,958,000
Total Wk. Oct. 28	95.2	2,399,400	65.5	31,218,000	135,431,000
Total Wk. Oct. 17	95.2	2,442,100	66.7	30,836,000	135,913,000
Total Oct. 25, 1930	95.6	2,342,400	65.7	†35,055,000	139,467,000
The Texas and Louisiana Gulf Coastal figures shown below are included above in the totals of their respective districts.					
Texas Gulf Coast	99.8	427,400	80.4	4,229,000	8,058,000
La. Gulf Coast	100.0	107,000	72.5	554,000	2,871,000

Daily Average Production

(Figures in Barrels)

	October 28, 1931	October 3, 1931	October 25, 1930
Oklahoma	482,500	273,500	537,450
Kansas	101,900	107,250	115,750
Panhandle Texas	65,050	64,200	81,200
North Texas	57,400	53,900	62,550
West Central Texas	26,950	25,400	47,000
West Texas	192,700	199 000	277,350
East Central Texas	56,250	57,250	40,800
East Texas	400,300	381,400	
Southwest Texas	56,000	55,300	112,600
North Louisiana	29,500	29,200	41,850
Arkansas	37,950	37,600	52,750
Coastal Texas	125,100	121,000	167,400
Coastal Louisiana	27,250	29,750	26,400
Eastern (not including Mich.)	107,100	110,150	115,000
Michigan	11,950	13,450	7,400
Wyoming	39,250	36,550	49,350
Montana	7,750	7,450	7,950
Colorado	4,450	4,300	4,200
New Mexico	43,800	43,100	38,050
California	508,100	497,700	593,150
Total	2,381,250	2,147,450	2,378,200

† Revised in Indiana-Illinois district, due to transfer to "Bulk Terminals" of stocks previously reported as "At Refineries."

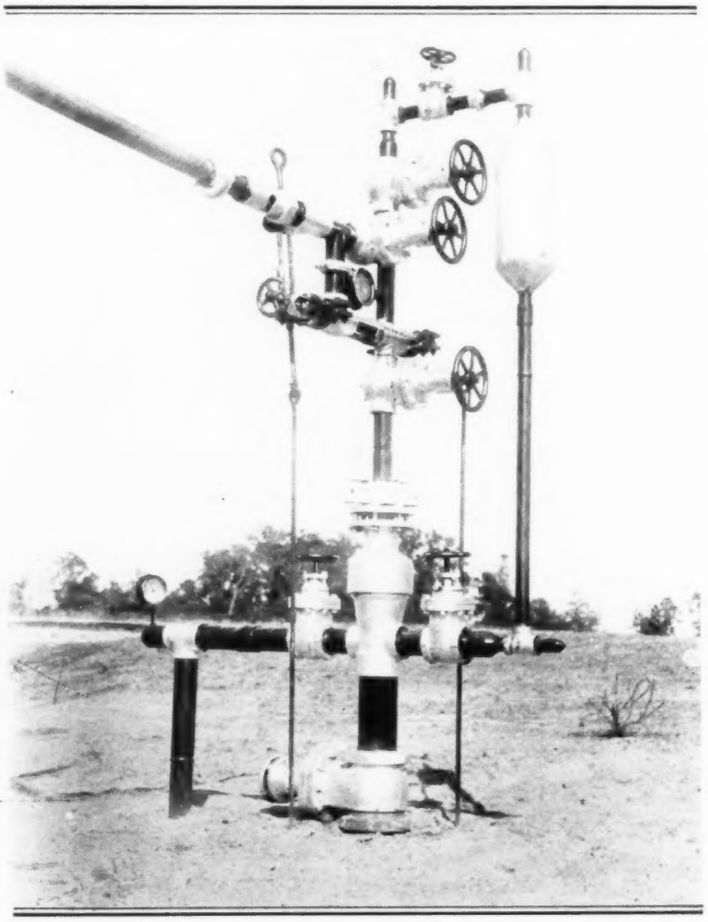
NOTE: In all the refining districts indicated except California, figures in this column represent gasoline stocks at refineries. In *California they represent the total inventory of finished gasoline and engine distillate held by reporting companies wherever located within continental United States (stocks at refineries, water terminals and all sales distributing stations, including products in transit thereto).

With Cold Weather Approaching A PROBLEM in the

WHEN winter comes, what shall we do to overcome paraffin trouble? This is the question that many operators in the East Texas field have been asking themselves the last few months. Already there is evidence that unless effective measures are taken to combat it, paraffin will be particularly troublesome during the coming winter. Paraffin trouble made its appearance in this field several months ago and the fact that it did so during the hottest months of the year is causing some apprehension among operators as to what might be expected when low winter temperatures prevail.

Paraffin has been found in the East Texas field in the tubing of flowing and pumping wells, in flow lines, in gas separators, and in stock tanks. While it appears thus far to be confined to certain wells in certain areas of the field, there is no doubt that eventually paraffin trouble will be prevalent in all parts of the field and that few, if any, wells will escape it. It is probably present in more wells than imagined but has just passed unnoticed up to now.

Analyses of the crude show that its general character does not vary greatly over the field, hence there is no reason to believe that its wax content varies in different parts of the field to the extent that paraffin trouble will not be encountered at some step in the combined operation of producing, gathering and storing the oil on the lease. A distillation analysis of the crude shows that about 50 per cent is fuel oil that solidifies at normal temperature because of the high wax content.



A flowing well in the Gladewater area, East Texas field, equipped with lubricator for feeding in chemical for paraffin trouble.

Bottom-hole temperature tests indicate that the original average reservoir temperature was about 152 degrees F. It is therefore a matter of surprise to many that at this early stage in the life of a field with such a relatively high temperature within the producing sand, a well's production should be choked off by the tubing becoming clogged with paraffin. Yet this has happened. On the west edge of the field in the proximity of the oil-water boundary in the producing horizon, the bottom-hole temperature is even higher; there, bottom-hole temperature readings of from 160 to 163 degrees F. have been obtained. The presence of edge and bottom water at this temperature along the west edge of the field should mitigate paraffin trouble in wells in these areas. In other parts of the field, however, especially the eastern half, where no water is present in the sand, paraffin is likely to be more troublesome because the chilling effect of the gas expanding as it is produced with the oil has nothing to offset it, and the reservoir temperature is bound to diminish as the field grows older.

Paraffin trouble has been prevalent in almost all the pumping wells in the Joiner area for some time. Paraffin deposits both on the sucker rods and in the tubing. Wells on the Calvin Young lease of the H. L. Hunt Company and the Melissa Pool lease of Roeser and Pendleton are reported to plug up with paraffin if shut down for more than two days. Also, before the martial law shut-down in the field, the tubing of several flowing wells in the field had become plugged with paraffin. At least four of these are known to have been plugged solid and the production of the well shut off entirely. They are: The Arkansas Fuel Oil Company's Annie Lee No. 1 in the Gladewater area, The Barnsdall Oil Company's McGrede No. 2, also in the Gladewater area, the Skipper Oil Company's Magrill No. 1, also in this area, and a well of the Houston Oil Company on the Nat Bean lease in the Kilgore area.

Several flowing wells in which paraffin trouble had never been suspected, when opened after the martial law shut-down, failed to flow. It was found that the tubing had become plugged with paraffin. The evidence indicates that in these wells the paraffin had probably deposited in the upper three or four hundred feet of tubing before the shut-down, but not enough to affect the well's flow. Then when the shut-down was ordered and the wells closed in, this deposit of paraffin in the tubing slumped or sloughed off, forming a bridge of wax. Had these wells not been shut down it is quite probable that they would have produced for a long time before paraffin in the tubing would have given any trouble and its presence recognized.

In the Joiner area the rock pressure, which is about 800 pounds, is very much lower than in other parts of the field. Any gas dissolved in the oil will come out of solution much farther down the hole than if the rock pressure were higher,

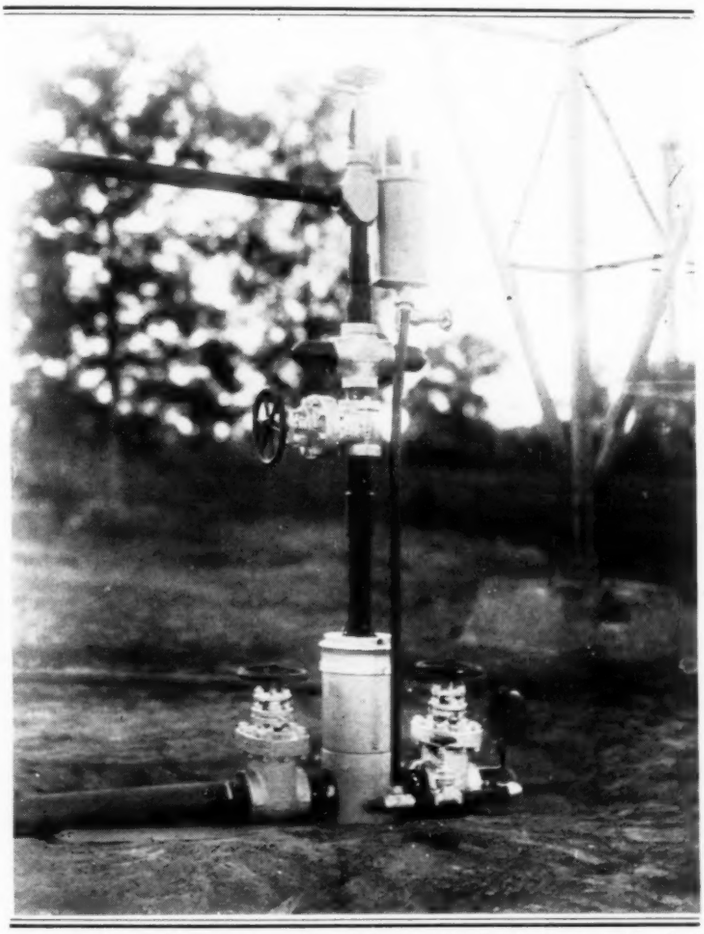
PARAFFIN TROUBLE LOOMS AS East Texas Field

By K. C. SCLATER

hence greater paraffin trouble is to be expected in this area than in other parts of the field. The problems that are encountered in the pumping wells of the Joiner area, however, are just a forerunner of what will be encountered in all parts of the field—excepting possibly the west edge—when the rock pressure has been depleted to the extent it has in the Joiner area.

In the flowing wells the greatest depth at which paraffin has been found in the tubing is about 400 feet.

Paraffin trouble has also been encountered in the traps and the lease tanks. One company reports an accumulation of 19 inches of B. S. in its stock tanks and that it was found to be composed almost entirely of paraffin. To obviate paraffin trouble in lease stock tanks many companies are installing a gun-barrel tank at each tank battery. All oil is run to it before it goes to the stock tanks. Several operators in the field are now busy equipping all old as well as new leases with gun-barrel tanks in preparation for the cold weather. By the use of the gun-barrel the Houston Oil Company has been able to hold the accumulation of paraffin over a period of several months to less than one inch in the stock or flow tanks. During this same period the accumulation of paraffin in the gun-barrel was from one to three feet. These gun-barrels are equipped with steam coils. Also many of the traps will be equipped with steam coils if the trouble becomes acute.



A flowing well in the East Texas field. Paraffin trouble in the tubing is the reason for the chemical lubricator hook-up.

There is yet little definite data available on the real extent of the trouble and the exact nature of the deposits in the East Texas field. The problem is now under close investigation by many operators in an effort to work out an effective method of combatting the trouble before winter puts in an appearance. Paraffin trouble in the oil fields is nothing new. It is encountered in greater or lesser degree in many oil fields. The nature of paraffin deposition does not vary greatly wherever encountered, but it does differ vastly in the degree of trouble it causes.

Often the local conditions will suggest the best remedy. In the East Texas field, it is certain that paraffin trouble will be present on every producing lease, if not now, eventually. Usually in a flowing well, whether paraffin is deposited in the tubing, the lead line, the trap or in the stock or flow tanks will depend to a large extent on how the well is produced. For wells in the East Texas field it can be said in general that at high rates of production the temperature of the oil at the casinghead is greater than at low rates of flow. At a high rate of production less gas comes out of solution as the oil rises to the surface than at a low rate of production, hence the chilling effect of the expanding gas is least at high rates of flow. It has been found that when wells in this field are allowed to flow their ratable production over a 24-hour period, the rate of production, and consequently the temperature at the top of the tubing, is low enough to cause serious paraffin trouble in the tubing. This is especially the case if a low tubing pressure on the upstream side of the flow bean is carried. East Texas crude carries a very high percentage of wet gases that come out of solution at pressures not far above atmospheric. This gas in expanding at relatively low pressures has a considerable chilling effect on the oil at pressures of 50 or 60 pounds above atmospheric pressures. Wells produced over a 24-hour period at the rate of 185 barrels daily and about 40 pounds trap pressure, have an oil temperature at the top of the tubing on the upstream side of the flow bean of between 60 and 70 degrees.

This low temperature of course causes the precipitation of paraffin and its deposition on the walls of the tubing. At low rates of flow, deposition is further aided by low flow velocities. Also if the well is heading it will aggravate the condition still further, especially if gas is produced between heads, and it usually is. A high velocity of flow in the tubing may prevent entirely the deposition of paraffin on the walls of the tubing. If the velocity of flow is great enough the particles of paraffin that are precipitated from solution are carried out of the tubing and into the lead lines or traps.

It is quite unlikely that wells on the west edge of the field will be seriously troubled with paraffin when they begin to make water in any amount. This is due to the combined effect of high water temperature, low gas-oil ratio and the ability of the water to carry off the paraffin particles even

This flowing well in the Kilgore area, East Texas field, already has been giving trouble with paraffin in the tubing although the well is but a few months old.

at relatively low velocity and preventing deposition in the tubing.

The depth of the paraffin in the tubing is governed largely, if not entirely, by the depth at which the rising column of fluid in the tubing—or casing for that matter—changes from what has been called the "foam" condition to the "mist" condition.[1] In the "foam" condition the gas is dispersed in liquid and in the "mist" condition the liquid is dispersed in gas. As the gas and oil flow up the tubing in the "mist" condition, slippage of the gas past the oil particles occurs. The gas slipping past the oil particles denudes the oil of some of its volatile constituents. This denuding action of the gas has a two-fold effect on the oil particles; first, vaporizing of the volatile constituents of the oil cools the oil particle, and second, stripping the oil particle of its volatile constituents decreases the solubility of the paraffin in the oil particle. This two-fold effect, or rather the result of this effect, increases toward the top of the tubing and paraffin is precipitated from solution. If the velocity of the gas is not great enough to carry the oil particle which is gradually increasing in density, it deposits on the walls of the tubing. Once the walls of the tubing become coated with paraffin the depositing action is accelerated. Examination of paraffin in the tubing of flowing wells shows that the deposit increases in thickness toward the top of the hole. Observation has also shown that the deposit rarely extends below the zone of "mist" flow or into the zone of "foam" flow. In the zone of "foam" flow there usually is present sufficient liquid to keep any paraffin present in suspension and prevent its depositing on the walls of the tubing. It should not be overlooked that the fluid velocity in the "mist" zone of flow may be great enough to eliminate entirely the deposition of paraffin in any part of the tubing.

It must be obvious that the lower the tubing pressure at the well head the greater will be the tendency for paraffin to deposit in the tubing. High pressure and a high flow velocity maintained in the top of the tubing of a flowing well will do much to reduce paraffin deposition in the tubing. This is especially important to keep in mind in the operation of flowing wells in the East Texas field. If the wells are flowed over a 24-hour period it is almost necessary that such wells be given special consideration of this kind.

Many operators have been able to keep the tubing in their flowing wells clean by periodically closing the tubing and flowing the well through the casing at a high rate of production for two hours or more. The high temperature of the oil in the casing at this high rate of flow is sufficient to melt the paraffin in tubing. The casing is then closed and the tubing opened up quickly so that the paraffin is blown out, leaving the tubing clean and ready to operate at a low rate of production if desired. Some operators are producing their wells by this method entirely, that is, opening up for a short period at a high rate of flow until the well makes its allowable production, and closing it in again.

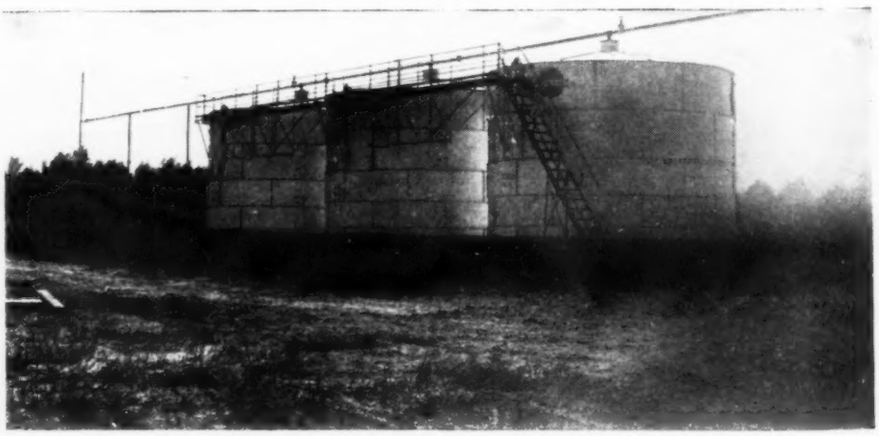
Chemical solvents have also been used with some success in removing paraffin from the tubing. There are many wells equipped with a lubricator for feeding chemical solvent into the well at required intervals. Chemical solvent is also used on the pumping wells in the Joiner area.

Mechanical scrapers are being considered by a number of operators as an economical method of keeping wells free from paraffin. Should the situation become acute, as it is likely to, during very cold spells, steam heating of the flow lines and traps may have to be resorted to. This method, it is believed, will be quite expensive in the East Texas field, and for that reason prohibitive.

The H. L. Hunt Company has used compressed air on its pumping wells in the Joiner area to remove plugs of paraffin from the tubing, but little information is available as to the success of this method.

Hot oil, heated at the surface and pumped down the casing outside the tubing has also been used in the field.

What method is adopted will depend on the over-all economies it will be possible to effect on the lease. With close to 3,000 producing wells in the field the necessity of finding a suitable method of coping effectively with paraffin trouble is obvious. Many ingenious and economical methods will no doubt be worked out by the time the paraffin troubles in the field become acute.



At this lease tank battery, East Texas field, from 9 to 14 inches of paraffin deposit has collected in the tank bottoms over a period of less than six months.

[1] "Some Principles Governing the Choice of Length and Diameter of Tubing in Oil Wells." by J. Versluys. A. I. M. E. Petroleum and Technology, 1931.

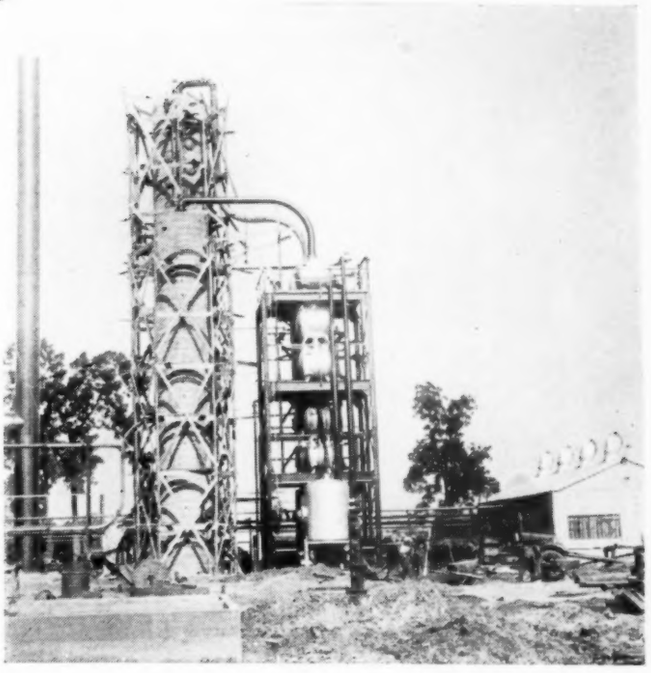
Refinery Engineering Progress Illustrated *by* East Texas Plant

By F. R. STALEY

CONSTRUCTION work was recently completed at the new refinery of the Petroleum Refractionating Corp. near Longview, Texas. The corporation is a subsidiary of the Bell Oil & Gas Co. of Tulsa, Okla. This plant was built to top and fractionate 10,000 barrels of East Texas crude per day. It is one of the best designed and equipped plants in this field, and embodies many of the latest engineering developments. The plant was built by the Southwestern Engineering Corporation.

The distillation unit and its auxiliary equipment is very compact and readily accessible for repairs, replacements, and cleaning. The picture of the pipe still shows the arrangement of the tubes. They are five inches in outside diameter, and set in Key junction boxes. The furnace walls are built with 22½ inches of firebrick, backed with two and one-half inches of insulating block, and finished on the outside with ⅜-inch transite. A Detrick flat arch is installed in the furnace. It is fired with fuel oil produced in the plant. Steel stacks are used for the pipe still and the boilers.

There are three bubble towers in the unit. The flash tower is 50 feet high, and 84 inches in diameter. The fractionating tower is 72 feet high, and 96 inches in diameter. The kerosene stripping tower is 12 feet high and 48 inches in diameter. Vapor heat exchangers, condensers, and receiving tanks are erected on structural steel supports beside the towers. The towers are insulated with four inches of rock wool. The Standard Asbestos Co. of Kansas City did this work. The exchangers and condensers are Southwestern type, short tubes in a steel shell. Neilan liquid level controls are used on the towers.

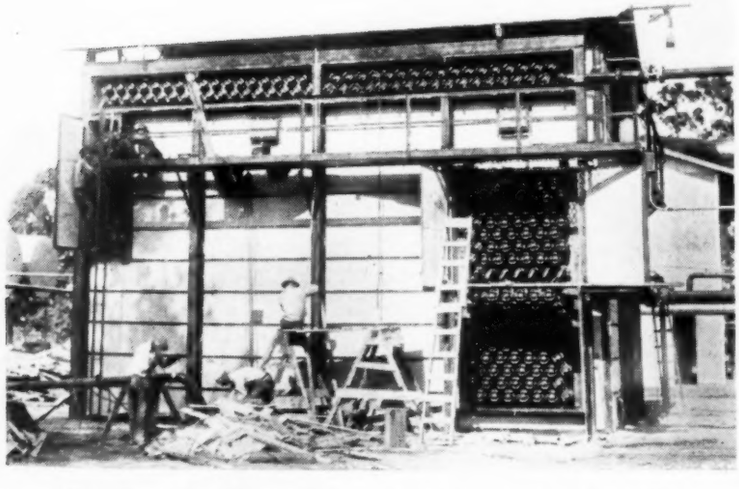


Fractionating towers and condensers under construction.

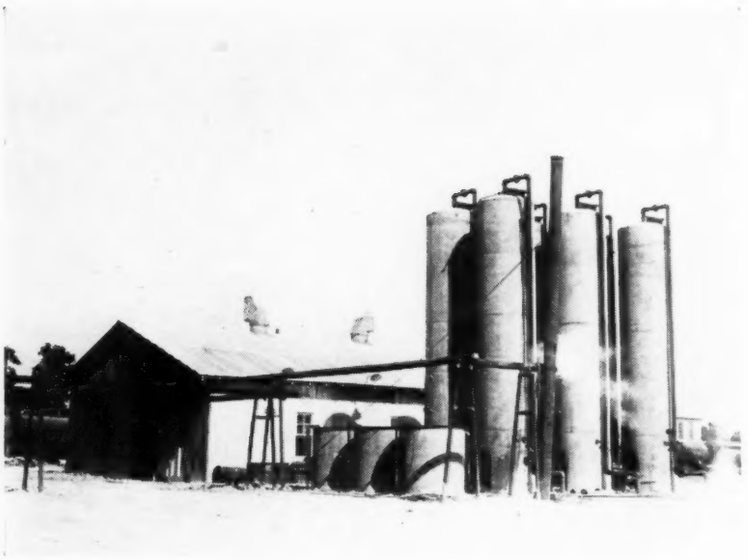
A one-story corrugated metal building conveniently located behind the towers serves as the pump room and receiving house for the unit. The control instruments are also located here. They are mounted flush on the panel board, although the cases are so designed that they can be mounted either way. The building is equipped with four roof ventilators to carry off gasoline vapors. Windows installed on all four sides of the building permit light to penetrate to all parts of the room. Provisions are made to make gravity determinations on the various streams from the towers.

The crude will be fractionated into the following cuts: gasoline, naphtha, kerosene, gas oil, and fuel. The railroad will take all of the fuel produced at the plant which is not required for its own use. The pour point of the crude is high due to its wax content. In order to pump it easily in cold weather, steam heating coils have been installed in the tanks, and a steam line through the fuel manifold on the loading rack.

The new Brown potentiometer recording and control instruments are installed on the distillation unit. Two of these instruments control the top tower temperatures, and a third the temperature of the oil from the pipe still. A 22-point master indicating potentiometer shows the various temperatures in the furnace, and the temperature of the oil at different points in the system. Some of the features of these new recording instruments are, the exceptionally wide chart which magnifies fluctuations from that desired, a humidity compensator corrects the reading for changes in atmospheric humidity, an oil immersed slide wire which keeps it constantly washed and lubricated, the galvanometer is protected from fumes and dust by a separate housing, rapid printing of the two temperatures, mercury switches sealed in glass



Pipe still at the Petroleum Refractionating plant, showing tube headers.



The treating plant.

eliminate relays and danger in the presence of explosive vapors. These are only a few of the important characteristics of the instruments.

Worthington steam pumps are used almost exclusively in the plant. Reciprocating pumps are used for charging, reflux, and transfer service. The two crude oil charging pumps for the unit are each 14x7½x18 inches. Two centrifugal pumps, rated at 2,400 gallons per minute each, driven by Terry steam turbines, are used to pump the water over the cooling tower.

A Marley redwood cooling tower having a capacity of 2,400 gallons per minute is installed. Water for the plant is obtained from wells, and from the city mains. A special system of water treatment has been devised for the boiler feed. The exhaust steam from the plant is condensed and recovered.

The boiler house, pump rooms, and other buildings in the refinery are constructed of steel and corrugated metal with concrete floors. There are two 500-horsepower Heine water tube boilers used to generate steam for the plant. Gardner feed water pumps are used, also a Cochrane feed water heater. Barco ground joint expansion joints are used on the steam lines. A concrete blow down pit is located behind the boiler house, also two welded tanks for fuel oil.

Wyatt welded tanks are used exclusively in the plant. This includes storage tanks, run down tanks, bulk filling tanks, and the towers in the treating plant. In order to have an accurate check on the crude fed to the unit, two 15,000 barrel welded tanks are erected nearby for run tanks.

Although the gasoline produced from East Texas crude is sweet, the naphtha and the kerosene require a little chemical treatment. The treating plant consists of six Wyatt towers, three open caustic mixing kettles, and the necessary pumps. Chapman valves are used extensively in the pump house. Sodium plumbite is used as a treating reagent.

The testing laboratory at the refinery is not very large, but it is very completely equipped and compact. It contains a large central room very well equipped with apparatus for testing the raw materials used in the plant, and the various products which are produced. The color and flash and fire tests are made in a small dark room. The building contains a stock room and one for retained samples of shipments. Crude oil is delivered to the refinery by pipe line. The company operates its own line in the East Texas field.

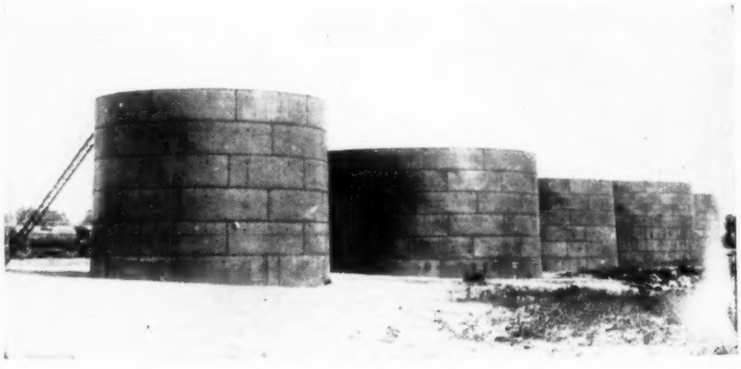
Rex Young, refinery engineer, is temporarily in charge of operations at the plant for the Petroleum Refractionating Corporation. F. H. Mitchell was in charge of construction for the Southwestern Engineering Corp.

Proration of the field has greatly reduced the quantity of this crude available to refiners, and consequently the refiners in this area will be compelled to use the most efficient refining methods to operate profitably. Most of the crude produced in East Texas is transported to the large refining centers which process it by cracking and refining its wax distillate for lubricating oils. There is little doubt that those refiners in the East Texas field that expect to survive will install cracking units or lubricating plants in order to obtain the maximum yield of valuable products from the crude.

East Texas crude is being refined in a variety of ways. The topping operation [1] yields about 20 to 25 per cent of high cold test fuel oil which has a limited market. Cracking the reduced crude or the gas oil yields a motor fuel of high octane number. The crude can be processed like other sweet Mid-Continent crudes to produce neutral oils and bright stocks. In order to manufacture these stocks the reduced crude can be acid treated, contact filtered, and dewaxed. But due to the fairly high treating loss, the better method is to vacuum distill the reduced crude, producing an overhead stock as a raw material for acid treating.

The U. S. Bureau of Mines recently issued a report of investigations 3130 on the Properties of Typical Crude Oils from the East Texas field. The report covers tests on samples of crude from the Joiner, Kilgore, Longview, and Van fields. To quote this report: The four samples of crude oil from the East Texas fields are all typical intermediate base crudes. All four samples have the same general characteristics. Each contains a small proportion of sulphur (average 0.28 per cent). The "total gasoline and naphtha," according to the United States Bureau of Mines method of interpretation of the analyses, averages 36.0 per cent, the kerosene distillate 9.6 per cent, and the medium lubricating distillate 6.2 per cent. The gas oil appears to be a good stock for the production of gasoline by cracking processes, and the lubricating distillates appear to be similar to distillates of the same ranges of viscosity obtained from Burbank, Oklahoma, crude, which is generally recognized as a high-grade refining crude.

[1] F. R. Staley, The Petroleum Engineer, June, 1931.



Storage tanks, Wyatt welded.

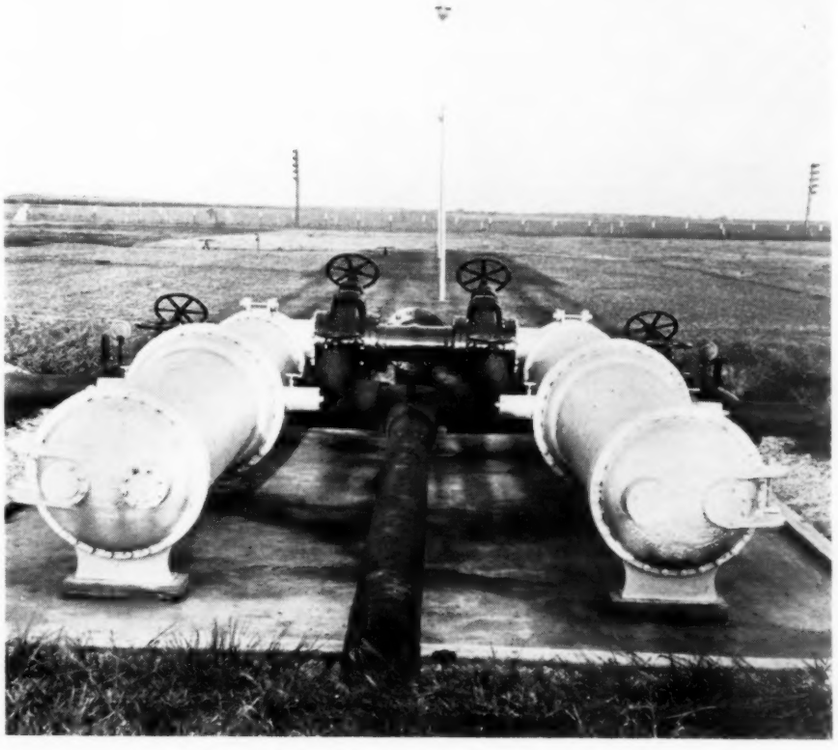
Turbine Pump Operates Closed Diesel Engine Cooling System

By

J. H. DAMERON

THERE are two fundamental requirements of an efficient and satisfactory water system for a Diesel engine plant. The first of these calls for a continuous and adequate flow of soft water through the engine jackets while the engine is in operation and the second is a reliable method of cooling the water after it has passed through the engine. In many cooling water system layouts it is sometimes difficult to attain all the requirements for a satisfactory cooling system.

Too frequently the water contains scale-forming impurities which are likely to precipitate at the temperature prevailing next the hottest surfaces — the vital sections of the cylinder head. In time, this scale restricts the volume of flow of cooling water, acts as a deterrent for heat radiation, and accelerates contraction and expansion of the metal until it loses its elasticity and fails. This condition along with a high temperature rise of the jacket water is attributed to be the cause of most cylinder head failures with subsequent costly shut downs for the units.



Dual installations of heat exchangers on main suction line.

The ideal system is one permitting a large volume of soft water through the engine jackets at a high velocity and with a low temperature rise. To this end several types of systems have been developed and more than 15 years ago a closed water system was developed for Diesel engine application. A few years ago the Gulf Pipe Line Co. developed a closed water cooling system that readily met the fundamental requirements of a satisfactory system and proved ideal for oil pipe line station work. The hot jacket water was cooled by circulating it through a heat exchanger located on the suction line of the reciprocating pumps.

This principle, with variations, is being used extensively by pipe line engineers in the design and construction of water cooling systems. One of the most recent installations of the closed cooling system is that of the Texas-Empire Pipe Line Co., at its Sheldon, Mo., station. Station equipment consists of three, five-cylinder, 600 h.p. vertical Diesel engines driving three 6¾x24 reciprocating pumps. The installation is compact and the station is housed in a brick building 97x55 feet with the equipment set at an angle 45 degrees from the building center line.

Two deep-well, over-capacity turbine pumps, one of which is a stand-by, are used to circulate the water. They take their suction from the hot well located beneath the office in the station building. Hot water is circulated through either one or both of the heat exchangers located outside the building and connected to the main suction line coming from the tank batteries. After passing through the cooling medium the cool water goes to the engine jackets and returns to the hot well to be recirculated.

A 100-barrel overhead cone-bottom tank located near the station main building floats on the circulating system lines. In the event the pumps fail for any reason, the overhead tank will insure water going through the engine jackets for a limited time, thus preventing operating the units without water. An alarm bell system has been devised to give a warning should the pump discharge pressure reach abnormal points.

The hot well is a concrete pit approximately 20 feet 5 inches by 10 feet 4 inches by 8 feet 4 inches, located beneath the station office in one end of the building. Location of the pit is a major factor in keeping it free of dirt, leaves and debris. Its only openings are for the piping connections, the pumps and a gauge port.

Cooling water is pumped from a well drilled on the premises. It is treated for hardness and then pumped to the system, either to fill it or as make-up water.

Both of the pumps are two-stage, over-capacity turbine pumps, fitted with a driving head for a 15-h. p. hollow shaft motor. Power for their operation is generated by one or both of the two generators operated in the station. They

operate at a speed of 1,760 r. p. m. By having over-capacity pumps, one pump will easily care for the load, leaving the other as a stand-by. Moreover, the over-capacity unit allows for a wider range of operation, and, once the valves on the water lines at the engine are set, the volume of water circulated may be controlled with the discharge gate on the pump in operation.

Normal operation of the station requires the running of two units and the outlet temperature of the jacket water is maintained at about 120 to 125 degrees, with a temperature rise of about 20 degrees. To accomplish this the discharge gate on the pump is pinched so the pump will deliver approximately 40 g. p. m. per 100 h. p.

Each engine is equipped with individual thermometers for each cylinder and a careful watch is kept on these by the operator. Should one cylinder start running hotter than the others, it may be brought to normal operating temperature by increasing the volume of water to the jacket by means of the valves on the engine's water lines. It has been found that, once the valves on the engines are set for desired operating temperatures, the changes due to day-to-day temperature variations may be met by opening or pinching the discharge valve on the pump. This, of course, will care only for the daily fluctuations in temperature during the various seasons of the year. More or less water may be circulated through the engines, depending on seasonal changes.

During normal summer temperature, ranging about 95 to 100 degrees, no trouble was experienced in maintaining the jacket water outlet temperature and temperature rise of the water. At that time a little more than a barrel of water was added daily to closed system supply. During cooler weather the amount of make-up water decreases substantially.

Like the pumps, the heat exchangers are a dual installation. Both are set on a concrete foundation and held secure by twelve ¾-inch bolts 12 inches long. Each exchanger contains about 2,200 square feet. The pit is located below ground level, offering less resistance to the suction crude on its way to the pump suction. Crude from station storage passes through the copper tubes in the heat exchanger and the water is circulated around the tubes. Station storage is located on an elevation high enough to give the oil in the suction line sufficient head to overcome the friction loss in going through the heat exchanger.

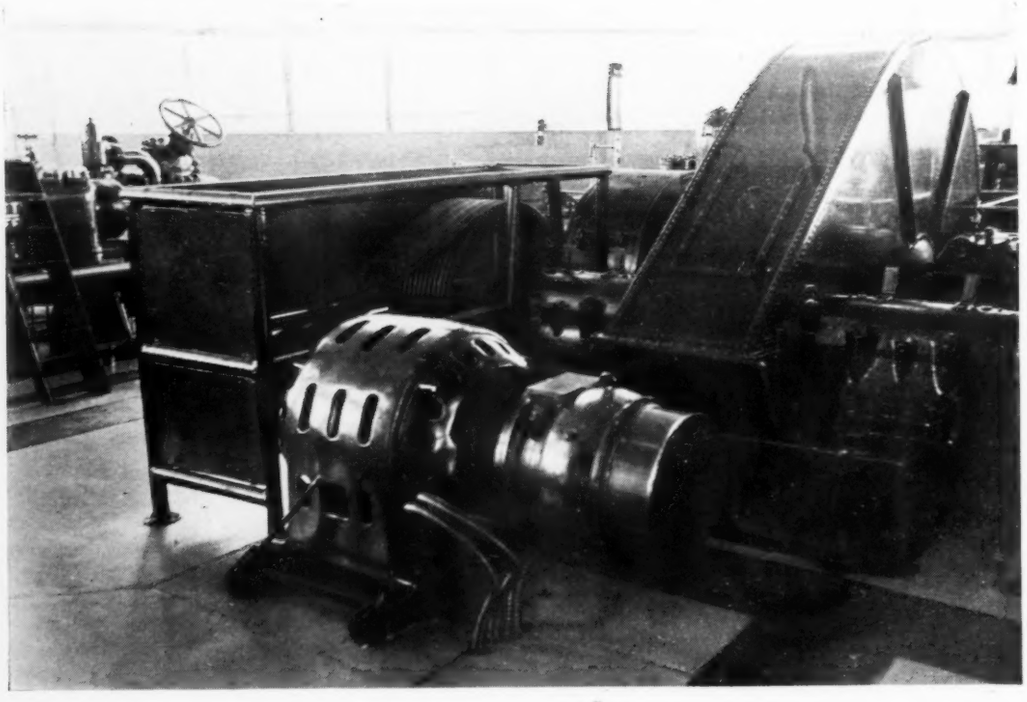
Suction crude comes down to the station through a 16-inch line from the tanks. This line is plugged at one end and two 12-inch lines from the inlet end of the exchangers tie into the 16-inch. Crude goes out through a 16-inch line on the outlet side.

The gate valve arrangement on the heat exchangers permits either the use of one exchanger or both. One exchanger will normally care for the station's cooling water requirements, leaving the other as a stand-by.

By having the heat exchangers interconnected, either one or both may be used, permitting repair or cleaning of the exchangers while the station is in operation.

Following a run of several months, going through both cold and hot weather, the exchangers were separately dismantled to determine if paraffin deposits were clogging the tubes. There was no trace of paraffin deposits, nor was any water present.

Electric power to drive the pumps and furnish light is sup-



Left—Turbine pumps for circulating water. Below—One of two generators furnishing power for pumps.

plied by the generators operating off the pinion shafts on No. 1 and No. 2 units through V-belt drives. One or both of these units are always in service except in the event of an extreme emergency. Should such an emergency develop, the auxiliary line driven generator would provide sufficient power to permit operation of the circulating pumps.

There is a remote possibility the engine would be subjected to the danger of an interruption of flow of water through the jackets. Such a condition for even a short time might not cause cylinder-head failure at the time, but it would cause an accelerated fatigued condition and a later breaking down of the metal walls. About the only possibility of running without water is in starting.

Should the operator start a unit and fail to open the valve on the inlet water line at the engine, the unit, of course, would be run until the error was discovered. Should the inlet water valve be opened and the pump not started, the overhead tank would insure water circulation for about an hour. Long before the tank was down, an alarm bell would ring, indicating trouble with the water system.

The alarm bell system, operating in connection with mercury switches, has been installed to give a warning should the water pressure on the circulating system raise above 30 pounds or go below 15 pounds. The volume of flow from the circulating pump is controlled by a gate valve on the pump discharge and this is pinched to meet the requirements of flow. Electrical warning signal connections are placed on the pump side of the gate. Should the gate be closed with the pump operating, the high pressure alarm switch functions, ringing the alarm, and should the pump lose suction the low pressure alarm would be sounded. Each pump has its separate gauges so that there is no possibility of the operators failing to change gauges when they change pumps.

Tied into the water circulating system is a piping layout to supply hot water to the lubricating oil centrifuge battery. Water of a temperature of about 200 degrees is required in the efficient operation of the centrifuge in purifying the crank case oil.

This water is heated by means of a jacket made with 12-inch pipe welded over the 8-inch engine exhaust line. This jacket is swaged at both ends and has a wrinkle expansion joint in the center to care for contraction and expansion. A jacket has been installed on each of the three engine exhaust lines. This system is filled with treated water by means of a connection on the engine water inlet line. It is circulated by a pump at the centrifuge.

The piping throughout the system is welded and all of the bends in the piping were made with fittings for welding in order to reduce friction losses to a minimum.

The closed system in connection with the turbine pumps affords the station an ideal cooling method. An adequate flow of water through the jackets is assured, as well as reasonable assurance of an uninterrupted flow, reliable cooling of the hot water and a low temperature rise of the cooling water circulating through the jackets.

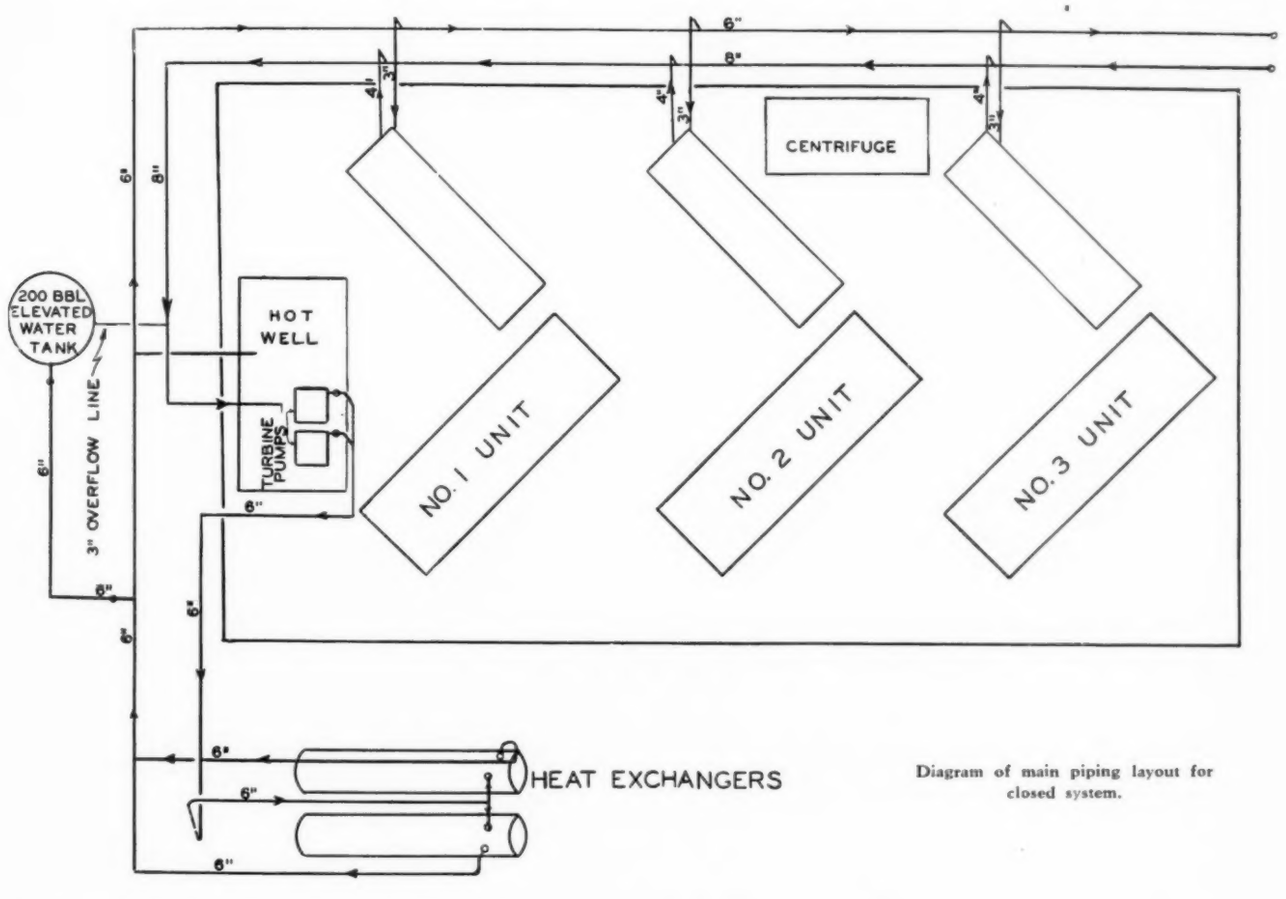
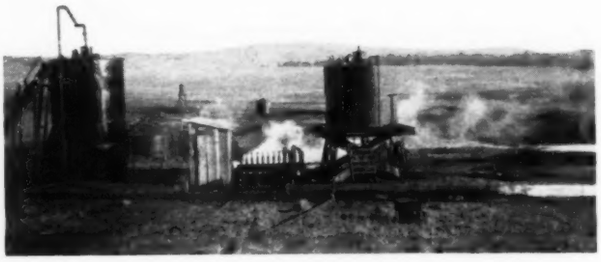


Diagram of main piping layout for closed system.

PRACTICAL METHODS *for* MAKING Individual Production Tests *of* "Stripper" Wells

By FRANK B. NEPTUNE,
Petroleum Engineer, Bartlesville, Okla.

IN recent years, oil operators have realized the importance of keeping records, not only of the profit and loss of *property* units, but of *well* units. They have come to realize that many times a property is kept out of the profit side of the ledger because of one or more wells which are not "paying their keep." Furthermore, most progressive operators have come to realize that intelligent repair work cannot be done among a group of wells without definite knowledge of what is and has been happening underground.



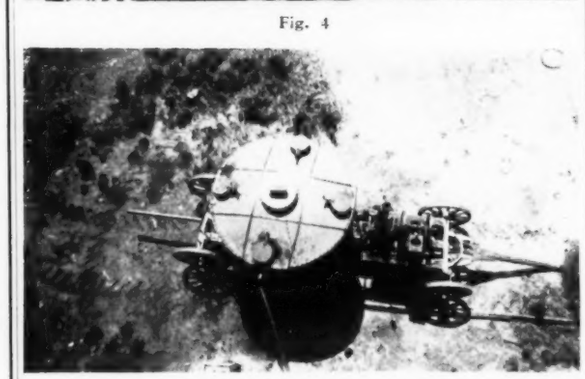
A tank battery in Osage County set with manifolds and special measuring tank for taking production tests of individual wells. By means of the manifolds, any well can be pumped through one manifold and into the gauge tank while other wells pump through the other manifold and into the regular lease gunbarrel. The measuring tank sets on the scaffold.

Step on any old lease and talk to the pumper. Very probably he can tell you within a fraction of a barrel what each well on his lease produces or what it "makes" as he terms it. He can also tell you which well makes the most salt water and that this well or that well "come on water" a "spell back." If he is unusually energetic and conscientious he may even have a record, for his own guidance, of when certain wells changed their producing status. But the chances are, if the well owner does not compel him to keep such a record, he will not. Few of us care to do more than we are required to do, and the oil field worker is no exception. But to get back on the lease; if you are in charge of or own a property with a small settled production that is just paying expenses and a little over (there aren't many such at this writing) and your pumper tells you of a well which in his opinion could be helped by cleaning out, if you do not have a record of each well's production for at least a few months back, how are you to judge the probabilities of getting your money back? If several wells are pumping through one gathering line, the chances are that even the pumper has only a faint idea of the producing status of each well. Even if the pumper can give fairly accurate information concerning the present oil and water production of each well, you have only a hazy picture. In the first place you have no way of knowing how fast water is encroaching or where it is coming from. The well in question may be directly in the path of a natural water flood and due to drown out any day. Or the well's individual decline curve (if you had it) might indicate natural depletion with only a slight probability of increased production even after cleaning out. On the other hand, if you had a record of the well's past production you might find that it had been a good producer and had "gone off" suddenly, indicating a possibility of restoring the well to its former producing status. Of course, mechanical details enter in strongly in deciding whether it is worth while to attempt repair, but unless you have something of the history of underground conditions as indicated by the records of the individual wells in the area you are liable to be "whistling in the dark" when you proceed with repair work.

Some producers view their wells as making so little oil as to be not worth "fooling with," but they certainly are "fooling with" any well that is hung on the power every day, for it requires the expenditure of a certain amount of mechanical energy to lift the rods and plunger whether the well pumps up fluid or not. Certainly no one would care to go to the expense and trouble of keeping a production curve for every stripper well, but if the operator has at hand the necessary records in the form of an occasional production test, it is a simple matter to plot curves showing the trend of the water and oil production of the well or wells in question. As a result of making a careful study of the property from the standpoint of the individual well, many operators have been able to place their leases on a more profitable basis, and in some cases to make paying properties out of losing ones.

A few years ago, when oil was worth as much as water, an operator in Oklahoma was considering drilling an inside well on an old property which had been producing

Fig. 4



Two views of portable well-testing apparatus. Upper view shows method of securing tank special wagon bed by means of turnbuckle. Also steel ladder for getting on top of tank to gauge. Lower view shows trusses made of old sucker rods and arrangement of gauge hatches making it unnecessary to level tank for gauging.

steadily, with a very small yearly decline, for more than ten years. A few years before, a string of rods had dropped, parting the tubing and damaging the hole so that it was finally plugged. This well was an inside well and until the accident that plugged the hole, was the best producer on the lease. It was several years later that the operator decided to drill another well near the plugged hole. The other wells on the lease were still producing steadily and no water had appeared. This operator had been requiring his pumpers to take a periodic production test of the individual wells and send the record into the office on a regular form. The tests had been made, the records sent to the office, where they were filed and forgotten. While necessary approval for drilling the well was being awaited, someone in the office dug out the well-test records and pointed out to the general superintendent the fact that the most recent production test on the lease, where it was proposed to drill the additional well, showed water appearing in two wells. As this property had never before been troubled with water, the superintendent sent one of the petroleum engineers to investigate. The engineer found that the properties to the north and west, which were lower structurally, had been literally drowned out during the preceding year by a natural water flood within the producing horizon. By perusing the available individual well records, the engineer was able to trace the path and progress of the water encroachment, and estimated it would be not more than six months until the water would be at the point where the proposed well was to be drilled. This is just one case where the right kind of record for the individual well saved considerable money. However, although there is little question of the value of this kind of information—the principal consideration is to obtain it with the minimum expense. The methods reviewed here are not necessarily original with the writer except in details worked out after several years experience in trying to get information on stripper wells without running the lease into the "red."

Fig. 3
Measuring oil and water production of a stripper well by means of gasoline drums. One drum is set up as a separating tank. Water is drawn off and measured from the bottom of the separating drum, while the oil flows from a connection near the middle through a one-inch hose into the measuring drums. The oil is pumped out of one drum while the other is filling.

Measuring With Oil or Gasoline Drums

Nearly every lease has a few gasoline drums or oil drums lying around. An oil drum with a side flange makes an excellent separating tank. A connection can be made easily in the bottom by placing a two-inch tank flange. The receiving drum should be set high enough to allow the measuring drums to be set at a convenient height below it. The measuring drum should be marked at the level representing 42 gallons as the average drum holds about 55 gallons. A connection for drawing off the salt water into one of the measuring drums should be made from the two-inch flange in the bottom of the separating drum; also an overflow connection for conducting the oil to the measuring drums. The lead line from the well should be broken at the flange at the wellhead, and a nipple (preferably a short joint of one inch), should be used to conduct the fluid from the well into the separating drum. After the salt water is drawn off the bottom of the separating drum and measured, it can be dumped; the oil, however, must be saved. The most convenient method of handling the oil is to hand-pump it back into the lead line and into the lease tanks. This makes it unnecessary to have more than three measuring drums, one for measuring the salt water and two for handling the oil. The discharge end of the hand pump is connected to the lead line. The suction end should have a hose connection so the hose can be inserted alternately in each drum as the other is being filled to the 42-gallon mark. If the overflow connection from the separating drum is a swinging one, it is not necessary to move the measuring drums while the test is in progress. Figure 3 shows an arrangement of drums for measuring the oil and water produced by a stripper. A short length of one-inch pipe connects the separating drum, which is set up on a scaffold, and the wellhead. The drum for measuring the salt water is set on the ground off the rig floor. The oil overflow connection is about half way up on the drum, and the oil flows through a piece of rubber hose which can be thrown alternately into each drum and thus obviate moving the drums. The suction hose of the hand pump is inserted in a drum which has just been filled and is ready to be pumped out.

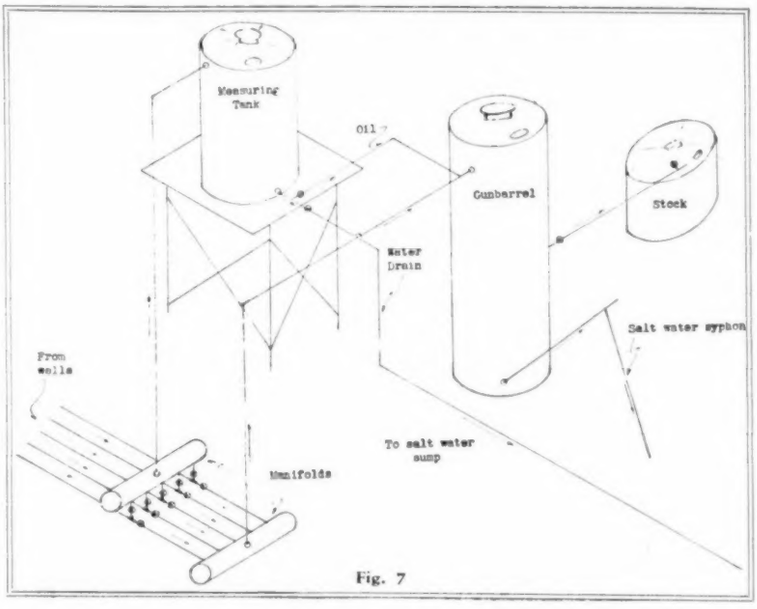


Fig. 7

Figure 1 shows a scaffold mounted on a sled which can be pulled from well to well. Figure 2 shows the portable scaffold with the separating and salt water drums in place.

Most of the material in this outfit could

be found about any lease.

A Portable Well-Testing Layout

Figures 4, 5 and 6 show several views of a portable outfit for testing wells which the writer designed and built several years ago for a company in the Mid-Continent operating many small oil wells. The apparatus consists of a 32-barrel steel gas-tight tank (made from the bottom ring of a 65-barrel tank) and a 3-h. p. gasoline engine and pump mounted on a lease wagon with special beams and hangers. The construction is shown clearly in the accompanying illustrations. The hangers were made in the company welding shop from old casing and the truss rods are old sucker rods. Four gauge hatches were placed on deck, making it unnecessary to level the tank for gauging. The outfit is pulled from lease to lease and from well to well by the district tractor. It is pulled up to a well to be tested, connection is made from the wellhead to one of the two-inch tank flanges on either side of the tank immediately under the deck ring, and the well production pumped into the portable tank. If the well is very small, the tank will hold several days' production. If the well pumps considerable fluid, it might be necessary to draw down the water every 24 hours. All water drawn off is, of course, measured. The well should be tested at least two days in order to insure greater accuracy. At the end of the test the accumulated oil is pumped into the lead line and to the lease tanks. The suction end of the pump is permanently connected to the bottom of the tank. A 2½-inch gasoline hose saves much time and trouble in making connection from the discharge end of the pump to the line. The complete apparatus shown here cost $625 to construct, of which $292 was the cash outlay. This cost could be reduced by using more salvage material. In this case a new tank was purchased. This apparatus, while more expensive to construct than the sled and drums, will give a more accurate test with less attention from the pumper while the testing is in progress. The outfit is very sturdy and will stand a great deal of abuse.

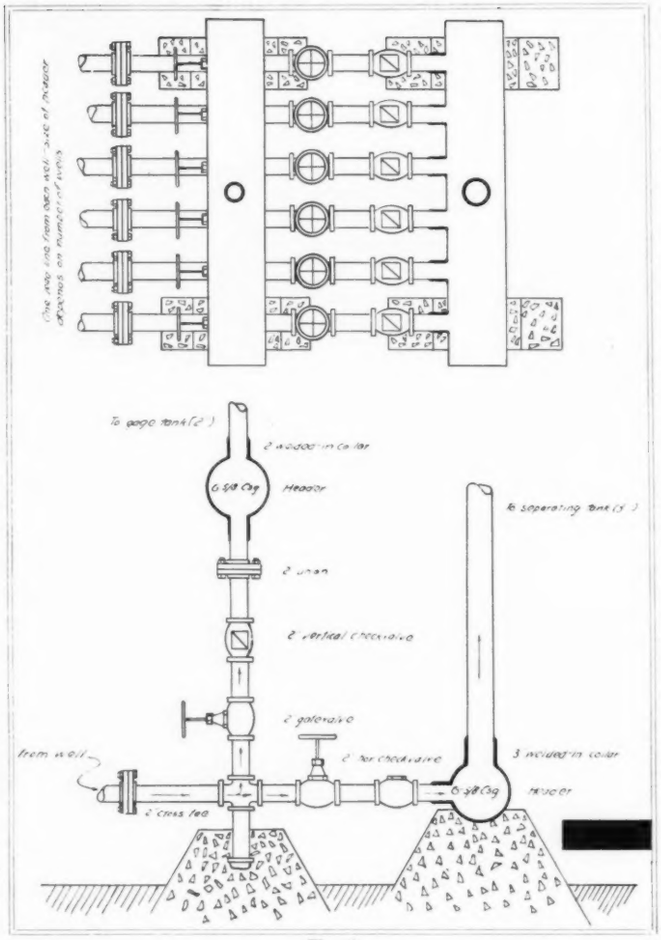


Fig. 8

Measuring With Gauge Tank and Manifold

Perhaps the most satisfactory method of taking regular production tests of the individual stripper well is by the use of two manifolds or headers and a special gauging tank. After the initial investment there is no further cost involved in securing production data. This method, with some variations, has been used in the field for several years by operators who felt the value of the information obtained would more than justify the additional expense. There are few old settled properties which could stand even the modest expense involved in this layout; the idea is to equip the property with the extra tank and manifold as soon as its production settles to the point where it is practical, and before the property has declined in production to the point where it will not stand the expense.

Almost all operators keep a record of each well's production while it is in the flush stage, but after it has declined past the flowing and air-lift stage and is put on the pump it is often connected to a common lease gathering line or connected to a common flow tank where the well

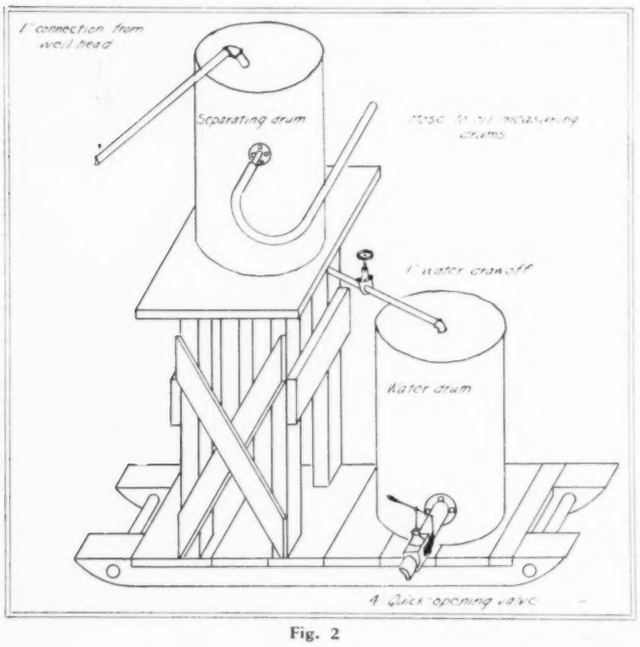


Fig. 2

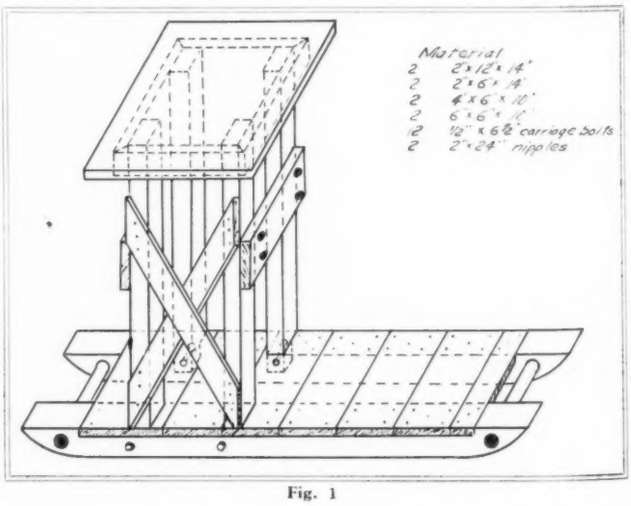


Fig. 1

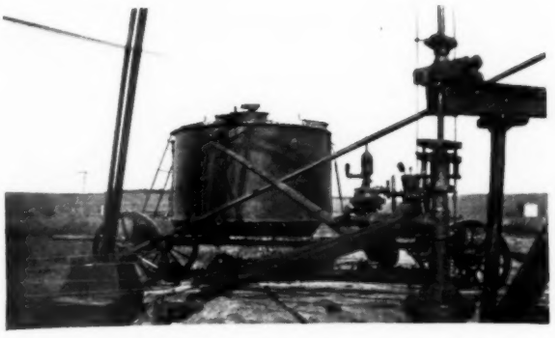


Fig. 5

Two views of the well-testing apparatus connected to pumping wells.

loses its individuality as far as records are concerned. At this point, while the lease is still above the point where the pumper has to rob enough oil from the district tractor to lubricate the polish rods, the extra tank and manifolds should be set. By this arrangement any well can be isolated and pumped into the gauge tank. Figure 7 shows a straight line drawing of a convenient method of hooking up the tank and manifold. In the arrangement shown, the oil makes no more right-angle turns than it would in the ordinary course. From Figure 8, which shows detail of connections, it can be easily seen how, by operation of the proper valves, any well can be isolated and made to produce into the gauge tank while the remainder of the wells are routed to the regular lease battery. The gauge tank or measuring tank is elevated in order that the oil will flow by gravity to the gun-barrel after the test has been made. The size of the gauge tank will, of course, depend upon the amount of oil and water the largest well on the lease produces, and the size of the manifolds depends upon the number of wells. The manifolds can be made from old casing by welding plates on the ends and welding couplings on the casing according to the size of the manifold. In making the manifold, couplings rather than nipples are preferable because couplings are less liable to have the threads damaged. From Figure 8 it can be seen that two separate manifolds are required and that they differ in detail of construction. The left-hand manifold handles the flow from the well on test. The outlet connection is directly opposite the inlet connections and, since it handles the oil from only a single well at a time, is the same size as the inlet connections. The right-hand manifold handles the flow from all wells on the lease except the well being tested. This manifold has the outlet connection at right angles to the inlet couplings and, because of the greater volume it must pass, the outlet coupling has the larger diameter. In the illustration the inlet couplings are two-inch, the outlet connection of the left-hand manifold is two-inch, but the outlet connection of the right-hand manifold is three-inch. These sizes of connections will be satisfactory for the ordinary property pumping settled production through two-inch lead lines. In operation the testing requires no more labor than setting the valves to isolate the well on test at the beginning of the pumping period, and gauging the tank at the close of the pumping period. For example (see Figure 7), if it is desired to test the well represented by the lead line on the extreme left on the sketch, the horizontal gate valve would be closed and the vertical gate valve opened. On the remainder of the lines the vertical valves would be closed against the flow and the horizontal valves would be opened. Vertical and horizontal refer to the position of the valve body and not the stem. This setting will send the production from one well to the gauge tank, while the remainder of the wells pump through the right-hand manifold into the regular gun-barrel tank. After the well on test has pumped off, the pumper measures the fluid in the tank, draws down the water, takes another gauge to determine the amount of water drawn off and then allows the accumulated oil to flow by gravity into the gun-barrel tank through the line marked "oil" on the drawing. The following day another well is isolated for test and the procedure repeated. In this way one well is tested every day and the interval between tests on any one well depends upon the number of wells connected into the manifolds.

(EDITOR'S NOTE: The concluding article of this series discussing methods of using individual well-test data to set up a lease "potential" and production ratio will appear next month.)

Fig. 6

Portable well-testing apparatus consisting of 32-barrel steel tank and gasoline engine and pump mounted on wagon base. After the well has pumped its production into the tank and the oil and water measured, the pump sends the oil to the regular lease tank battery.

Fig. 1.—Characteristic appearance of a sucker rod pin failure showing the fracture to have originated at the root of the last perfect thread.

SUCKER RODS

4. Why They Break[1]

By C. G. zur HORST[2] and BLAINE B. WESCOTT[3]

IN order to consummate the development of sucker rods capable of providing satisfactory service under the most severe operating conditions it is essential to know where failures occur most frequently in the rods and to be acquainted with the underlying causes contributing to the failures.

Classification of Failures

Data assembled from nearly ten thousand sucker rod failures have shown four distinctive and characteristic types which occur in surprisingly constant ratios but slightly affected by the type of rods used or the service conditions under which they operate. Three of these types of failures have been quite generally recognized for years and therefore do not require detailed consideration. Briefly, they are: pin failures which occur in the threaded portion of the pins, box failures which occur in the threaded portion of the boxes or couplings and body failures which occur in the body portion of the rods. The fourth type occurs in the body within a distance of one foot from the upset section at either end of the rods. For descriptive purposes this type may be termed neck failures. Three factors contribute to the frequency of neck failures, stress concentration induced by the more or less abrupt change in section, reduced flexibility caused by the adjacent rigid joint sections and, in some cases, weakened areas in the rods resulting from manufacturing methods.

The classification of sucker rod failures for a selected group of the heavier pumping wells in Texas and Louisiana during 1930 is given in Table 1. It is evident that the failures are essentially equally divided between the joints and bodies.

Table 1. Classification of Sucker Rod Failures in Texas and Louisiana Wells for 1930

Type of Failure	Number	Per Cent
Pin	1,763	25.3
Box	846	12.2
Body	1,968	28.3
Neck	1,626	23.4
Unscrew	752	10.8
Total	6,955	100.0
Average Number of Wells	2,290	
Average Number of Rods in Service	200,762	
Average Depth of Wells (feet)	2,190	

The characteristic appearance of pin breaks is pictured in Figure 1. Invariably the failure is located in the section which marks the junction between the perfect threads and the imperfect vanishing threads. Experiments performed with celluloid models for the photoelastic analysis of stress distribution have indicated that in threaded joints over 60 per cent of the total load is carried by the last two threads and this conclusion affords a ready explanation for the location of pin failures exemplified by Figure 1. A group of three typical box failures and one body failure is illustrated in Figure 2. Loss of metal by wear against the tubing was the principal factor contributing to all four failures. If defective material or workmanship are disregarded, it may safely be assumed that practically all box failures are directly attributable to wear. Representative body and neck failures are shown in Figure 3.

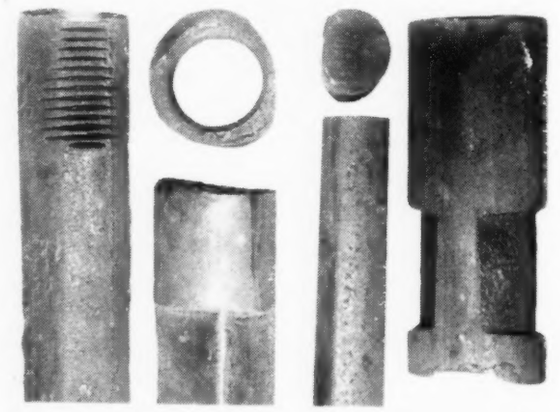


Fig. 2.—Typical box and body failures resulting from wear against the tubing.

Occasionally failures are traceable to flaws in the material or imperfections in fabrication. Figure 4 gives two examples of this nature; the rod on the left failed because of a cold shut seam extending entirely around the fillet while the rod on the right failed because of improper relationship between the various steps by which the pin was upset. In the latter instance the irregular nature of metal flow in the end of the pin is clearly distinguishable in the photograph.

The Nature of Fatigue Failures

Irrespective of the type or their location in the rods, all field failures exhibit the common characteristic of rupture unaccompanied by any readily discernible elongation or reduction of cross sectional area. This appearance is general to progressive fractures that result from subjection of many metals, including steel, to repeated applications of stress. They are called fatigue failures and the property of a metal which opposes this action is termed the fatigue or endurance resistance. The fatigue or endurance limit[4] then

Fig. 3.—(Left) Body failure of sucker rod. (Right) Neck failure of sucker rod.

[1] The fourth of a series of articles on sucker rods.

[2] Materials Engineering Division, Gulf Research Laboratory, Pittsburgh, Pa.

[3] Engineer of Tests, Gulf Research Laboratory, Pittsburgh, Pa.

[4] Moore and Kommers, The Fatigue of Metals.

is the greatest unit stress below which the metal will withstand an indefinitely large number of cycles of stress without failure for any given set of conditions. There is no precise relationship between the endurance limit of a metal and its other physical properties although there is a somewhat indefinite correlation between that property and tensile strength; the term efficiency ratio has been suggested[5] to express this relation. The extreme values for efficiency ratio have been shown to be 0.61 and 0.35, while the majority of steels give values varying between 0.40 and 0.50. The endurance limit is subject to the influence of operating conditions such as the nature of the stress (flexure, shear, torsion, tensile), the range of stress (algebraic difference between maximum and and minimum stresses) and the rate of stress application especially where corrosion is present. Other factors which modify the value of this property are internal flaws, abrupt changes in cross section, condition of the surface and internal stress. A detailed consideration of these many factors is clearly beyond the scope of this article.

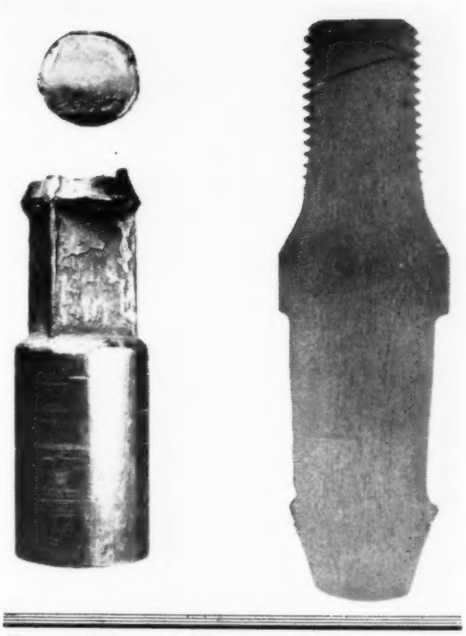


Fig. 4.—Sucker rod failures resulting from defective forging. (Left) Cold shut steam extending entirely around the fillet. (Right) Non-uniform flow of metal in the end of the pin.

Sucker rod failures are frequently ascribed to "crystallization" or "salt water crystallization" thus tacitly implying that the internal structure of the metal has altered and that there has been a change in physical properties, notably a loss of ductility. There is also the further implication that fractures caused by static stresses are fundamentally different from those resulting from dynamic stresses. All of these suppositions are untrue.

It has been established[6] as a fact that all metals in the solid state have a crystalline structure which is preserved even under severe plastic deformation. When the strain is great enough to cause permanent deformation such action is accomplished by a process of slippage within the crystals. To envision this phenomenon it is helpful to recall that X-ray analysis has shown that a metal crystal is composed of atoms disposed in simple geometric arrangement in a regularly repeated manner throughout. This regular assemblage of atoms which makes up the crystal is known as the space lattice of the metal and it has a definite orientation and planes of weakness. The millions of crystals in a piece of metal are oriented in all possible directions and this statistical distribution of the planes of weakness accounts for the remarkable constancy attained in the properties of manufactured metal products. The application of force results in distortion of the space lattice and, if its magnitude is great enough, permanent deformation is brought about by rupture of atomic bonds along favorably oriented planes of weakness. This action results in a general rearrangement of interatomic forces which are sometimes stronger than the original ones, e. g., cold drawn steel. Ductility of metals is possible because the atomic arrangement is such as to permit permanent deformation to occur by this process of slip. The effects of slip are visible under the microscope and are pictured in Figure 5.

With this brief consideration of the crystal structure of metals and the effect of strain upon the atomic arrangement within the crystals it is possible to postulate the actual mechanism of fatigue failures of sucker rods. In the pumping operation at the start of the upstroke the rods are under a static or dead load equivalent to the weight of the rods less the buoyant effect of the fluid in the tubing. During the upstroke the rods are subjected to a superposed live or dynamic load equivalent to the force necessary to accelerate the total weight of rods and fluid from a position of rest to the maximum velocity attained. On the downstroke the dynamic load is decreased by the deceleration of the load made up of the weight of the rods and by the transfer of the

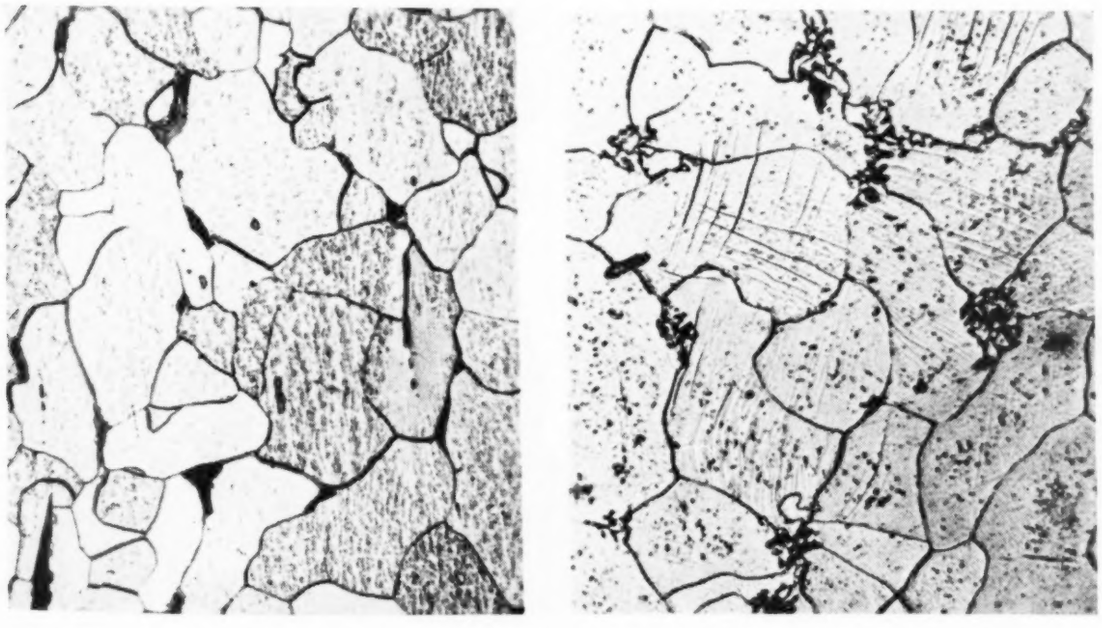


Fig. 5.—Effect of strain in causing slip in mild steel. (Left) Metal in unstrained condition. (Right) Slip bands in the strained metal. Magnification 500 diameters.

[5] H. J. Gough, The Fatigue of Metals.

[6] J. A. Ewing and W. Rosenhain, The Crystalline Structure of Metals, Phil. Trans. Roy. Soc., A., Vol. 193, 1900.

Fig. 6.—Slightly enlarged view of a body failure in a ¾-inch sucker rod illustrating the progressive nature of failure.

weight of the fluid to the tubing. The rods are therefore subjected to repeated dynamic stresses between maximum and minimum limits in tension. Because of differences in their direction of orientation, the crystals of the metal in the rods are unevenly strained, and the constant repetition of stress causes slip to begin in certain favorably oriented crystals. Continued application of vibratory stresses results eventually in slip that is of sufficient magnitude to form a crack of microscopic size. Further repetitive stressing enlarges the crack at a gradual but continually increasing rate both because there is stress concentration at the ends of the crack and because the continual diminution of sectional area constantly increases the unit stress. Finally the unit stress attains such magnitude by reason of the reduced area that the remainder of the section fails rapidly.

The progressive nature of fatigue failures is readily apparent in the appearance of the fractures typically illustrated by a slightly enlarged view of a body failure in a ¾-inch rod in Figure 6. Three clearly defined zones are visible, corresponding to distinct differences in the rate of propagation of the crack. The failure began at the top surface and proceeded very slowly toward the center of the rod. The smooth appearance of the fracture in this first zone is the result of the rubbing of the faces against each other and proves that the failure progressed at a slow rate. When the crack reached approximately half way through the rod the area of sound metal was so reduced that the advance of the crack became more rapid as evidenced by the rougher surface. Rupture occurred suddenly after the crack had progressed nearly through the rod, being accompanied by elongation and reduction of area of the remaining metal.

The Relation Between Failures by Static and Repetitive Stresses

The nature of the last stage of failure by fatigue in which rupture occurs suddenly supplies convincing evidence for the belief that there is no fundamental difference between this type of failure and that caused by increasing static tension. Both types are pictured in Figure 7. The rod on the left was broken in tension and exhibits the characteristic elongation and reduction of area universally associated with this type of failure in ductile metals. The rod on the right is a field failure and exhibits no perceptible elongation or reduction of area. Figure 8 reproduces the structures at the points of failure of specimens prepared from the same piece of steel; the sample on the left was broken in tension, that on the right was broken in fatigue. The crystalline structure of both is evident and so is the extensive plastic deformation of the former and the almost total absence of such action in the latter.

The sameness of principle underlying the action under the two kinds of stress may be clarified by an analogy[5] in which the crystals are represented by two decks of cards (Figure 9). The cards represent the planes along which the atoms are grouped and the spaces between the cards correspond to the planes of weakness within the crystal. Application of a continually increasing static load in the direction indicated by the arrow to the deck on the left in Figure 9 induces deformation by a process of relative slipping between adjacent cards until the local deformation becomes great enough to result in rupture. Application of vibratory stresses to the deck on the right, as indicated, having a low mean value also causes relative slippage between adjacent cards but in this case the deformation occurs in two directions from a mean point of low load. Rupture eventually occurs in this case also but with very slight net deformation because of the bi-directional manner of loading while in the previous case the loading was uni-directional and deformation extensive. It is clear that aggregates of crystals treated in the two manners described will have appearances at failure corresponding to those in Figure 7.

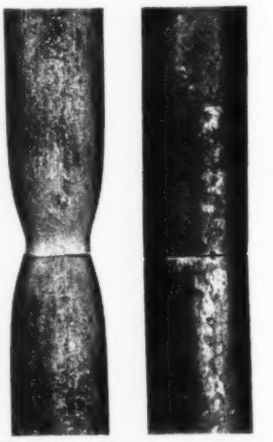


Fig. 7.—(Left) Failure caused by static tension showing extensive deformation. (Right) Failure caused by fatigue showing no deformation.

Corrosion Fatigue

It was pointed out earlier that the endurance limit of a given steel was not a fixed value and that it was influenced by variations in the service conditions. It is only in the past five years[7] that the effect of corrosion on the ability of steel to withstand repeated stressing has

[7] D. J. McAdam, Jr.: Stress-strain-cycle Relationship and Corrosion Fatigue of Metals. Proc. Am. Soc. Test. Mat. (1926) 26, Pt. II, 224.

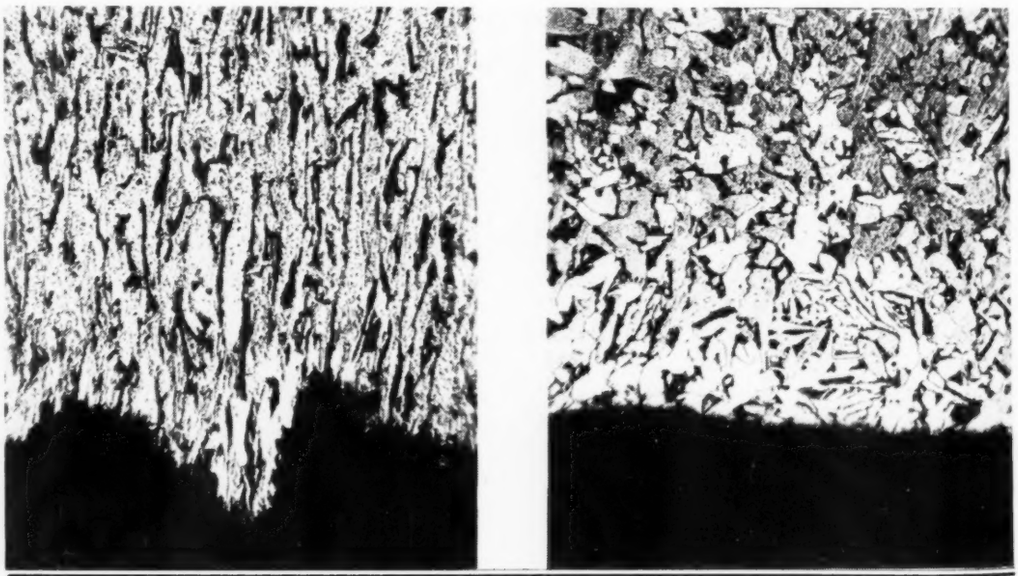


Fig. 8.—Structures at the points of failure of specimens prepared from the same piece of steel. (Left) Extensive deformation caused by static tension. (Right) Lack of deformation resulting from fatigue. Magnification 100 diameters.

been fully realized. The action of vibratory stresses in the presence of a corrosive medium has been termed corrosion fatigue and the corrosion fatigue limit of a steel is the greatest stress which can be indefinitely applied to it without failure under any given set of corrosive conditions. The consideration in some detail of this phase of the endurance resistance of metals is important since nearly all sucker rods are required to operate in the presence of well water which is usually a brine of high saline content and considerable corrosivity.

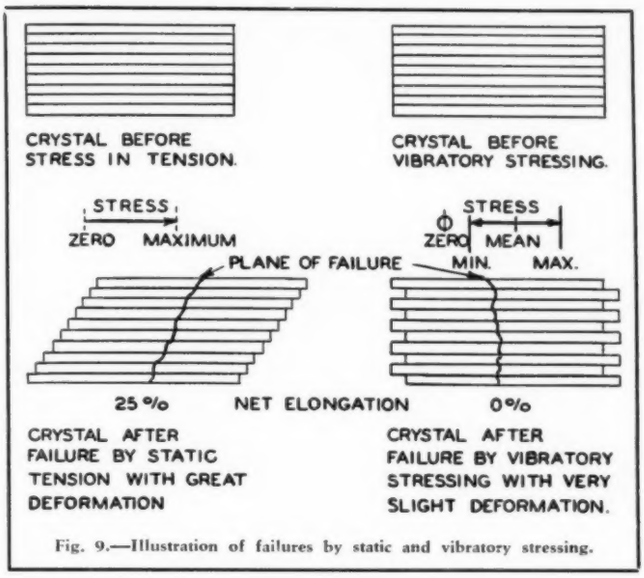


Fig. 9.—Illustration of failures by static and vibratory stressing.

Because of the great amount of data which has been accumulated since the importance of this action was first recognized it will be necessary to limit this discussion to a summary of some of the more pertinent conclusions.

The corrosion fatigue limit of all ordinary steels (plain carbon and common alloy) is very much less than the fatigue limit so that the net result of the combined action of corrosion and fatigue is the reduction of the magnitude of the repeated stresses necessary to produce failure. Whereas in ordinary fatigue (without corrosion) a proportionality exists between the tensile strength and fatigue limit, no such relation has been found in corrosion fatigue. The most significant fact brought out is that the corrosion fatigue limits of all common steels are very nearly the same when exposed to the same corrosive conditions regardless of their physical properties or composition. The corrosion resistances of the common steels do not vary greatly[8], thus justifying the opinion that the corrosion fatigue limit of a steel is primarily dependent upon its corrosion resistance and is but slightly influenced by other properties.

The corrosion fatigue limit is influenced greatly by the degree of corrosivity of the corroding medium but even slight corrosion simultaneous with fatigue will cause failure at stresses far below the ordinary endurance limit. The extent of damage is therefore variable and can be stated with certainty only when all conditions of service are definitely fixed. In general, severe corrosion prior to service in fatigue is much less damaging than mild corrosion in conjunction with fatigue.

A very satisfactory theory to explain the action of corrosion fatigue has been suggested[9] and, since it applies directly to many field failures, it will be outlined briefly. The rate of corrosion (solution) of a metal is largely determined by an inherent property called its solution pressure which assumes a definite value under any given conditions of corrosion. The first stage in the process of corrosion fatigue is the corrosion of the metal, which action generally results in the formation of pits. The force controlling this action is the solution pressure of the metal increased because of the cyclic nature of stressing to which it is subjected. As pit formation proceeds, both the actual stress and the effective solution pressure are intensified, the former because of the usual stress concentration at a change in section and the latter because of increase of the former. The mutual intensification of stress and solution pressure proceeds with increasing effect until the stress at the bottom of the pits exceeds the endurance limit of the metal. The second stage of failure here begins; it is ordinary fatigue accelerated by corrosion and the rupture takes place in the manner described for ordinary fatigue failures. In service where the initial stress is above the endurance limit the first stage of corrosion fatigue is absent and the action is that of fatigue accelerated by corrosion. Severe corrosion fatigue is generally accompanied by the formation of small cracks at right angles to the direction of stress at the base of the corrosion pits.

The intimate connection between the theory of corrosion fatigue and the failures of sucker rods is clearly illustrated by Figures 10 to 12 inclusive. Figure 10 pictures a group of rods in which corrosion was intensified by pumping stresses which were not severe enough, however, to cause actual failure. The rod at the extreme right is illustrative of the increase of solution pressure by internal stress. The area of severe localized corrosion coincides with the point where the normalizing treatment stopped, leaving the metal internally stressed because of the temperature gradient over the section. It is interesting to note that this attack took place in six months service and was entirely prevented by the use of fully normalized rods. The concentration of stress at the bottom of a corrosion pit caused the failure pictured in Figure 11. The sectional views at the top prove without question that the failure originated at the pit. The actual size of the pit would ordinarily appear inconsequential. Figure 12 provides a typical example of severe corrosion fatigue resulting in transverse cracks at the bottoms of the corrosion pits.

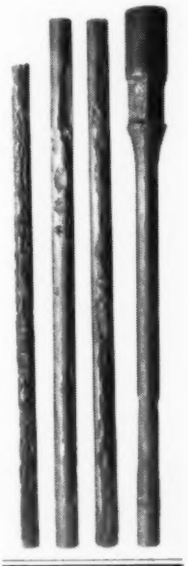


Fig. 10.—Corrosion of sucker rods intensified by stresses imposed by pumping.

Hydrogen Sulfide Embrittlement

In many fields, notably those in West Texas, the effect of corrosion fatigue is intensified by the presence of hydrogen sulfide. The natural corrosivity of the water is greatly increased by the presence of dissolved hydrogen sulfide[10] and the corrosion endurance limit of steel under such conditions is materially decreased. The damaging effect of hydrogen sulfide is not confined solely to increasing the corrosive attack, however, since, in the presence of moisture, gaseous hydrogen sulfide embrittles the steel.[11] The exact nature of sulfide embrittlement has not been established. It is analogous in every way to the embrittlement resulting from acid pickling of steel, therefore suggesting as the most probable explanation that nascent hydrogen, formed from the interaction of hydrogen

[8] F. N. Speller: Corrosion, Causes and Prevention.
[9] D. J. McAdam, Jr.; Fatigue and Corrosion Fatigue of Metals. Proc. Inter-Nat. Cong. Test Mat. 1927.
[10] S. H. Gill, Corrosion of Production Equipment, Eleventh Annual Meeting, American Petroleum Institute, Chicago; November, 1930.
[11] B. B. Wescott and L. W. Vollmer, Effect of Hydrogen Sulfide on Wire Rope. Trans. A. S. M. E., Pet. -52-7-39.

sulfide and steel, is adsorbed by the steel mainly along the intercrystalline boundaries. The degree of embrittlement is increased by pre-existent internal stresses in the metal so that the proportion of neck failures is greater in sulfide areas. Following the tendency which has been pointed out[10] for highly corrosive fields, the severity of attack is greatest near the bottoms of the wells. Sucker rod records of three high sulfide wells are given in Table 2 which discloses several significant departures from general conditions. In normal operations it has been found that 70 per cent or more of all sucker rod failures are concentrated in the top 1,000 feet of the wells, a fact easily predicted from an analysis of stress conditions. However, from Table 2 it is clear that more than 50 per cent of the total failures occur in the bottom 1,500 feet of high sulfide wells. This condition is somewhat remarkable in view of the light loads in the bottom portion of the strings. From the earlier discussions of corrosion fatigue and embrittlement it should follow that severity of conditions in these respects would result in some increase in the proportion of body failures and a marked increase in the proportion of neck failures, because of the stressed condition of the metal in the latter sections. Comparison of Tables 1 and 2 shows that total body failures in normal operations average 50 per cent but that the average in high sulfide operations exceeds 80 per cent. Practically all of this increase takes place in the proportion of neck failures.

Table 2. Records of Sucker Rods in Sulfide Fields

Well No.	1	2	3
Depth	2,835	2,819	3,015
Size of Pump (in.)	2½	2½	3
Size of Tubing (in.)	2½	2½	3
Pumping Speed (strokes per min.)	22	20	21
Length of Stroke (in.)	55	55	36
Production			
Oil (bbl.)	120	25	140
Water (bbl.)	20	25	140
Sucker Rod Service (days)	834	658	264
Total Sucker Rod Failures	79	42	89
Classification of Sucker Rod Failures			
Pin (per cent)	11.4	2.4	16.9
Box (per cent)	0.0	0.0	0.0
Body (per cent)	25.3	52.4	29.2
Neck (per cent)	59.5	45.2	50.6
Unscrew (per cent)	3.8	0.0	3.4
Average Depth of Failures (ft.)	1,590	1,650	1,710
Failures in Bottom 1,500 Feet (per cent)	58.2	64.3	56.2

Suggested Improvements

The foregoing analysis of the distribution of sucker rod failures and the manner in which they occur suggests several possible methods for the improvement of sucker rod quality.

Pin failures are caused by fatigue which is hastened by stress concentration and uneven loading. There is little doubt that the design of the A. P. I. joint could be modified in such a manner as to decrease the stress concentration in the last perfect thread and provide a more uniform loading of the pin. Many neck failures may likewise be attributed to stress concentration resulting from the abrupt change in section between the body of the rod and the forged ends and the use of a long fillet between these two sections would produce beneficial effect.

It may logically be concluded that practically all body failures are due to corrosion fatigue. In view of the present knowledge of corrosion fatigue it appears quite certain that no worth-while progress against body failures will be recorded by the use of heat treated sucker rods unless these rods are fabricated from a steel that is inherently more corrosion resistant than ordinary plain carbon or alloy steels.

The perfection of a protective coating for sucker rods is difficult because of the several requirements which are essential for success. It must be corrosion resistant to salt water either in the absence or presence of hydrogen sulfide and should preferably be electropositive to steel. It must be susceptible to ready application to steel with a bond of sufficient strength to withstand the elastic deformation of the rods in pumping. Last, but not least, it should be cheap. No coating offered up to the present complies fully with these requirements.

Composite metals consisting of ordinary steel with thin outer coatings of some more corrosion resistant alloy such as nickel or stainless steel are being rapidly perfected for many purposes but there are several factors which render their value for sucker rods problematical. There has been a recent mild revival of interest in wrought iron for sucker rods but at best it can only be said that it still remains to be demonstrated that wrought iron is more corrosion resistant than steel for general underground oil well service. Even were such a superiority to be definitely established the use of wrought iron sucker rods would be confined to light pumping service because of the low endurance limit of the material. In this event, however, there is undoubtedly a real field for a composite material made up of a steel core with a thin covering of wrought iron. It is of interest to note that such a material is available.

After all, the sucker rod problem, in common with those of related items of well equipment, is strictly one of economics, where it is necessary to establish the proper balance between initial investment and ultimate service. In the light of past experience and present knowledge the most probable solution appears to be the utilization of comparatively cheap alloy steels with corrosion resistant properties intermediate between those of ordinary steels and the real corrosion resistant alloys.

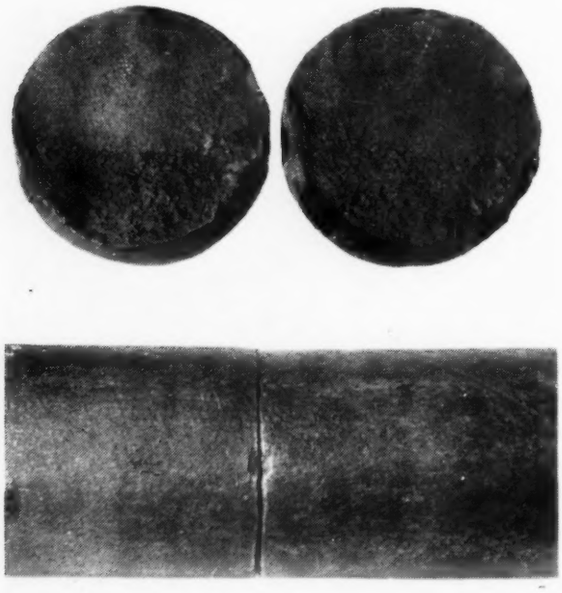


Fig. 11.—(Left) Sucker rod failure resulting from concentration of stress at the bottom of a corrosion pit.

Fig. 12.—(Right) Appearance of sucker rods after service under severe conditions of corrosion fatigue.

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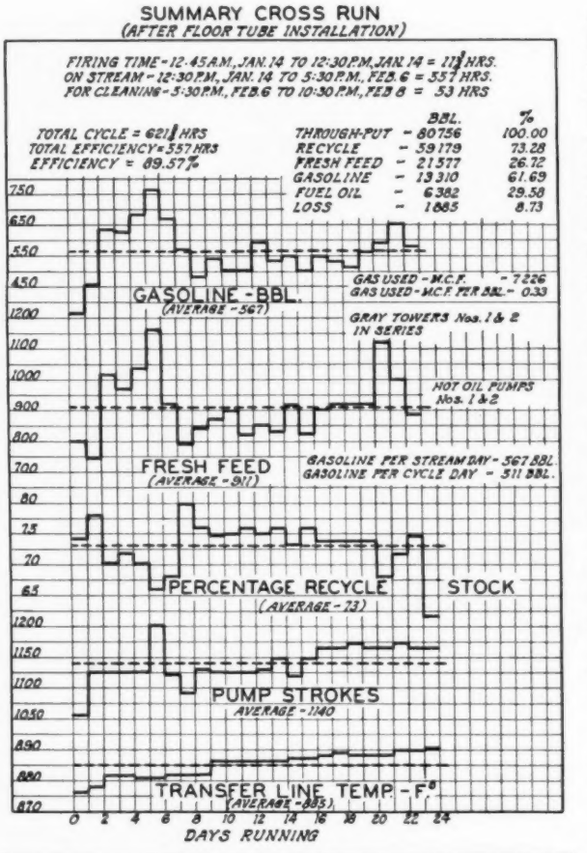
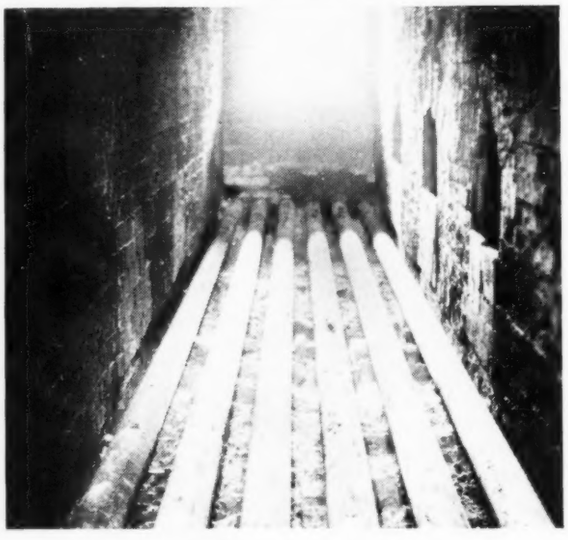
Texas Pacific Coal and Oil Co.

WITH the continued clamor for a high anti-knock and low-priced gasoline, the refiner has been forced to seek ways and means of producing this product at the lowest possible cost and so he has looked to his cracking plant as the solution and the means of accomplishing this result. Changes and improvements in the cracking phase of the industry have been rapid, so that now the cracking process has changed from a special piece of equipment that could operate only on a clean, selected charging stock to one that can take almost any kind of petroleum as a raw feed and convert it into the maximum yield of gasoline and at the same time produce a marketable fuel oil and remain on stream for a satisfactory period of time. Many units have undergone changes with the view of increasing their capacity or yields, and most of them have accomplished their purpose to a satisfactory degree.

The Texas Pacific Coal & Oil Company operates a Cross cracking unit which was built several years ago and, at a comparatively small expense, increased its capacity 30 to 35 per cent, and at the same time has changed the flow so as to run a certain percentage of fuel oil or other residual charging stock. In order to more thoroughly understand the changes made, a brief description of the original operation will be given. This unit was built as a 500-barrel, fresh feed, hot oil cracking plant and was operated in the conventional manner with a throughput of approximately 600 barrels fresh feed per day, yielding 63 per cent gasoline of 415 end point; and carrying a recycle ratio of 3 to 1. The gasoline is treated in the vapor state in Gray towers. The cracking stock was Ranger gas oil and the gasoline produced required 2.0 c. c. tetra Ethyl lead to bring it to Ethyl standard. This unit is equipped with a carborundum furnace.

The unit is fired through six Carborundum muffles or tunnels, about twelve feet in length. The gases produced by the complete combustion of the fuel in these muffles then passes through a wall into the convection section of the furnace, then directly upward through the tube banks into the stack. Above the six muffles are 32 tubes, called the radiant bank because of the fact that their heat is obtained by radiation from the hot tile muffles below. The remainder of the tubes are in the convection section of the furnace and consist of a lower bank of 30 tubes called the convection bank and an upper bank of 25 tubes known as the preheater section.


SUMMARY CROSS RUN
(AFTER FLOOR TUBE INSTALLATION)
FIRING TIME - 12:45 A.M., JAN. 14 TO 12:30 P.M., JAN. 14 = 11½ HRS.
ON STREAM - 12:30 P.M., JAN. 14 TO 5:30 P.M., FEB. 6 = 557 HRS.
FOR CLEANING - 5:30 P.M., FEB. 6 TO 10:30 P.M., FEB. 8 = 53 HRS
TOTAL CYCLE = 621½ HRS
TOTAL EFFICIENCY = 557 HRS
EFFICIENCY = 89.57%
BBL. %
THROUGH-PUT - 80756 100.00
RECYCLE - 59179 73.28
FRESH FEED - 21577 26.72
GASOLINE - 13310 61.69
FUEL OIL - 6382 29.58
LOSS - 1885 8.73
GASOLINE - BBL.
(AVERAGE - 567)
GAS USED - M.C.F. - 7226
GAS USED - M.C.F. PER BBL. - 0.33
GRAY TOWERS Nos. 1 & 2 IN SERIES
HOT OIL PUMPS Nos. 1 & 2
FRESH FEED
(AVERAGE - 911)
GASOLINE PER STREAM DAY - 567 BBL.
GASOLINE PER CYCLE DAY - 511 BBL.
PERCENTAGE RECYCLE
(AVERAGE - 73)
STOCK
PUMP STROKES
AVERAGE - 1140
TRANSFER LINE TEMP. - F°
(AVERAGE - 883)
DAYS RUNNING



View of floor tubes.

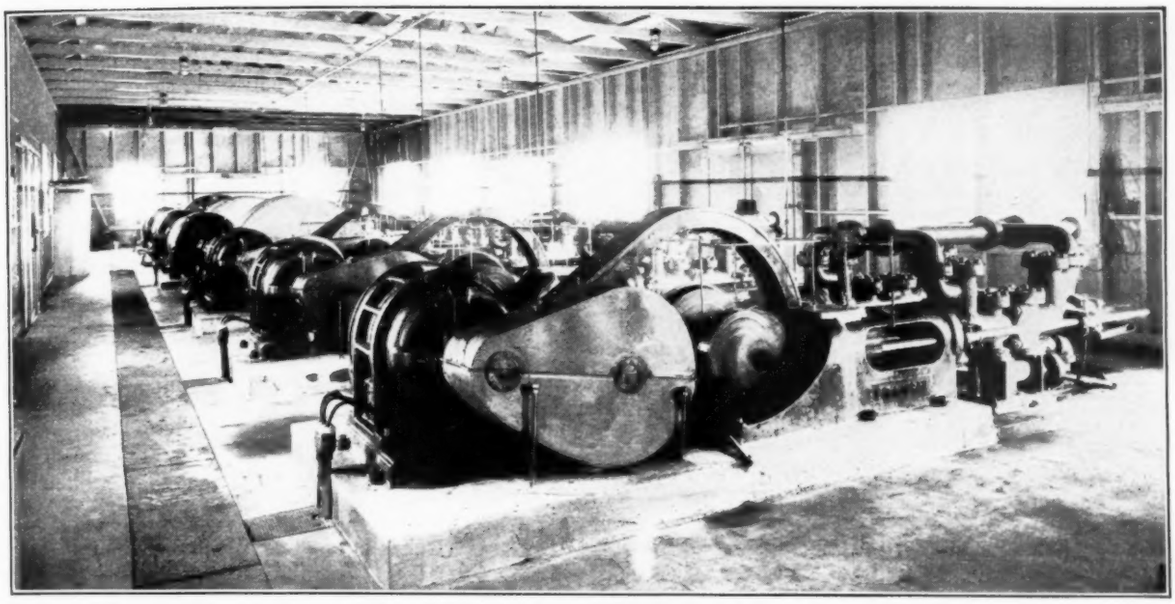
The hot oil is fed to the unit from an accumulator tank by a Hot Oil Pump, going first to the preheater bank where it enters at a temperature of 580 degrees F., then flows to the convection bank entering at 625 degrees F. and thence to the radiant bank where it enters at 800 degrees F. The oil discharges from this bank to the chamber has a temperature of 875 degrees F. The feed entering the tubes is made up of recycle stock from the bubble tower and fresh gas oil. This gas oil is charged to the unit through a series of coils in the tops of the bubble tower and evaporator where it is preheated to approximately the same temperature as the recycle stock from the bubble tower. The evaporator tower originally contained spiral tile in the top, the purpose of which was to knock back the heavier ends so that they could be withdrawn with the residue.

Furnace temperatures as high as 1600 degrees F. were carried in the convection section of the furnace and the temperatures over the Carborundum muffles were carried at 1250-1300 degrees F.

The operation of this unit was very successful as we were able to obtain satisfactory yields with long runs, the unit having an average, since its installation, of 26 days on stream per run, with a record run of 44 days. Tube failures were rare in spite of the fact that the unit has been pushed hard. When it became necessary for the refinery to produce more gasoline without increasing the crude run it was decided, after much thought and deliberation, to install floor tubes in the unit.

In order to make the installation, the unit was shut down for a period of eight days and of this time, two days were

Six Strong—Dependable



PIPE LINE *Pumps*
IN A ROW

SIX strong, dependable pipe line pumps in a row, running smoothly and quietly.

Where there is considerable variation in the amount of oil to be pumped, a flexible installation of many units, like the above, is the last word in station efficiency.

If you have to do with the operation of a pipe line, may we suggest that you investigate these TRANSIT Texas Type pipe line pumps. We will take pleasure in giving you the details.

Address the Home Office, or any District Office of the company.

REFINERY PUMPS
FOR HOT OIL
and every other refinery service
TRANSIT (CURTIS) ROTARY PUMPS
PIPE LINE PUMPS

BEAUMONT, TEXAS
E. L. Wilson Hardware Company
SALT LAKE CITY, UTAH
F. C. Richmond Machinery Co.

NATIONAL TRANSIT PUMP & MACHINE CO.
OIL CITY, PA.

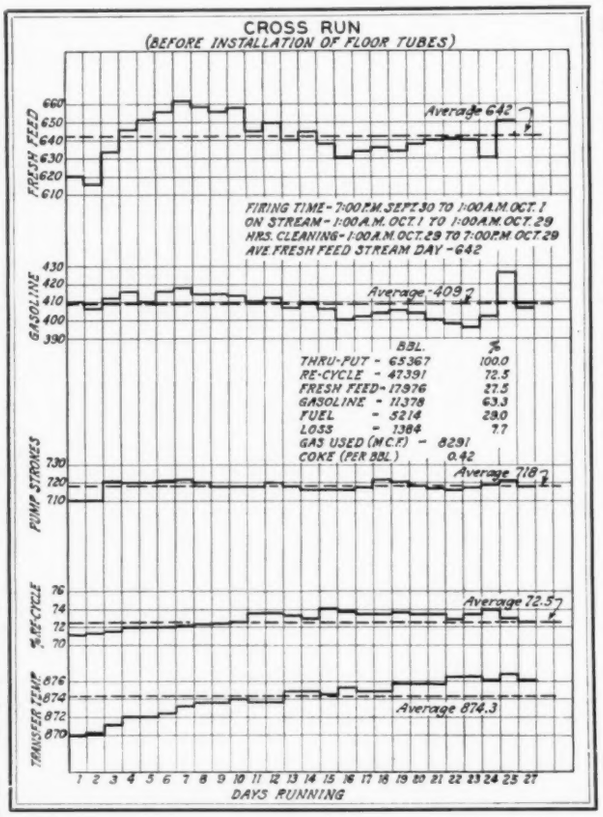
PHOENIX, ARIZ.
Pratt-Gilbert Co.
LOS ANGELES
Republic Supply Company of California
ST. LOUIS, MO.
Reeves & Skinner Machinery Co.

NEW YORK PHILADELPHIA CLEVELAND PITTSBURGH LOS ANGELES HOUSTON TULSA NEW ORLEANS

FIELD PUMPS
TOOLS
for Pipe Line Construction
GAS ENGINES
GAS ENGINE GAS COMPRESSORS

required to cool the equipment before work could begin and another two days were required for drying out and bringing the unit on stream, so that only four days were required to do the work; at the same time, several other minor changes were made in the piping and towers. These will be taken up later.

The installation was made as follows: The 12-inch ducts through which air had been admitted for supporting the combustion were removed. This was necessary so that the new floor tubes could be set low enough to prevent flame impingement on them. These were then replaced with six 6x18-inch air ducts and these covered by an insulating material and used as supports for the new floor tubes. The walls at each end of the furnace, to a height of four feet, were torn out and replaced with a lintel, consisting of a 4-inch channel and two 4-inch I beams, with a 1-inch steel plate on top, which was to support the walls above the tube headers. The header box and tube sheet were set under this lintel and the six floor tubes were then installed, five of them being the 24-foot length tubes as used elsewhere in the unit and the sixth being a 26-foot tube, the last used for the purpose of making the cross-over. All these tubes were regular seamless carbon steel cracking tubes, 3-inch inside diameter by 4-inch outside diameter. Special key headers with 6¾-inch centers were rolled on the tubes; these were made special because of the fact that smaller centers were necessary due to the comparatively small space available for the installation.


CROSS RUN
(BEFORE INSTALLATION OF FLOOR TUBES)
FRESH FEED
Average 642
FIRING TIME - 7:00 P.M. SEPT. 30 TO 1:00 A.M. OCT. 1
ON STREAM - 1:00 A.M. OCT. 1 TO 1:00 A.M. OCT. 29
HRS. CLEANING - 1:00 A.M. OCT. 29 TO 7:00 P.M. OCT. 29
AVE. FRESH FEED STREAM DAY - 642
GASOLINE
Average 409
BBL.
%
THRU-PUT - 65367 100.0
RE-CYCLE - 47391 72.5
FRESH FEED - 17976 27.5
GASOLINE - 11378 63.3
FUEL - 5214 29.0
LOSS - 1384 7.7
GAS USED (M.C.F.) - 8291
COKE (PER BBL.) 0.42
PUMP STROKES
Average 718
% RE-CYCLE
Average 72.5
TRANSFER TEMP.
Average 874.3
DAYS RUNNING

The end tube on the first and second row of the convection bank were then removed, as it was necessary to install new headers in order to make the connections with the floor tubes, the tube on the second row being connected to the floor tube directly under by an offset, which was put in by key terminal and corner fittings. The tube on the bottom convection row was connected to the 26-foot floor tube on the opposite end by a bend. The job was then tested with 1500 pounds cold oil pressure without a leak developing.

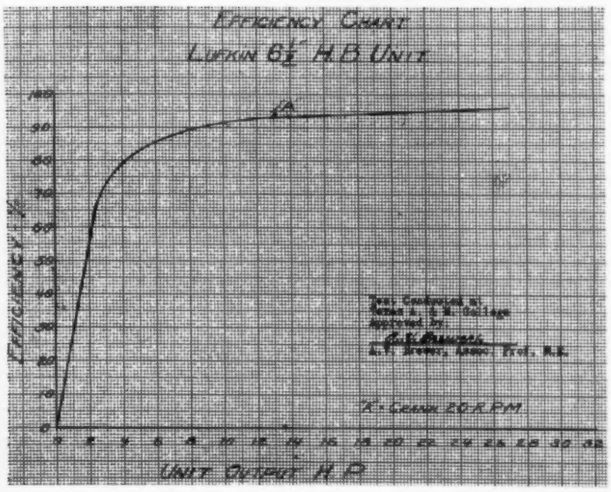
At the same time, connections were made for the interjection of feed direct into the evaporator. This was done by utilizing the coils going through the two towers and discharging it into the evaporator instead of the accumulator. All tile in the top of the evaporator was removed in order to prevent too much condensation. The discharge of the trim coil was then connected to the accumulator in order to provide any additional hot feed if it was found necessary to do so.

On starting up the unit, it was found that the lines from the chamber to the evaporator were of insufficient size due to the increased throughput and these were changed at the end of the first run. The flow of the oil through the tubes was somewhat changed by the installation. The hot oil now enters at the same temperature as previously, namely 580 degrees F. and enters the convection section at approximately the same temperature as before the change. With the new installation, the oil now passes through the first 25 tubes of the convection section and then enters the floor tubes at a temperature of 685 degrees F., returns to the bottom row of convection tubes at a temperature of 780 degrees F. and passes on to the radiant section and chamber as before.

The floor tubes have been in use for almost one year and the results have been very gratifying, as may be noted from the production curves. Other than the increased throughput the most noteworthy effect has been the lower furnace temperatures that have been observed since the installation was made, namely, 1500 degrees F. in the convection section as an average whereas this temperature was previously carried as high as 1600 degrees F. No coking trouble has been experienced in these floor tubes and it is only necessary to polish them with the star cutters even after an exceptionally long run; however, it may be mentioned that somewhat harder coke is deposited in the radiant section. Tube life has been satisfactory although two tubes have ruptured after 125,000 barrels of fresh feed had been put through them. The installation has been very flexible in that higher recycle ratios and higher out-let temperatures than previously held, could be carried with the resultant increase in the anti-knock value of the gasoline produced. The tetra-ethyl lead requirements now run from 1 to 1.3 c.c. per gallon. The capacity of the unit was increased from 650 to 900 barrels of fresh feed per day with approximately the same percentage of gasoline yield. Also by aid of higher outlet temperatures and other changes mentioned, we have been able to put as high as 35 per cent of fuel or other dirty stock direct into the evaporator, flashing off the clean stock for cracking and leaving the dirty residue in the evaporator to be drawn off with the fuel and at no time has the B. S. content of the fuel been above .8 per cent.

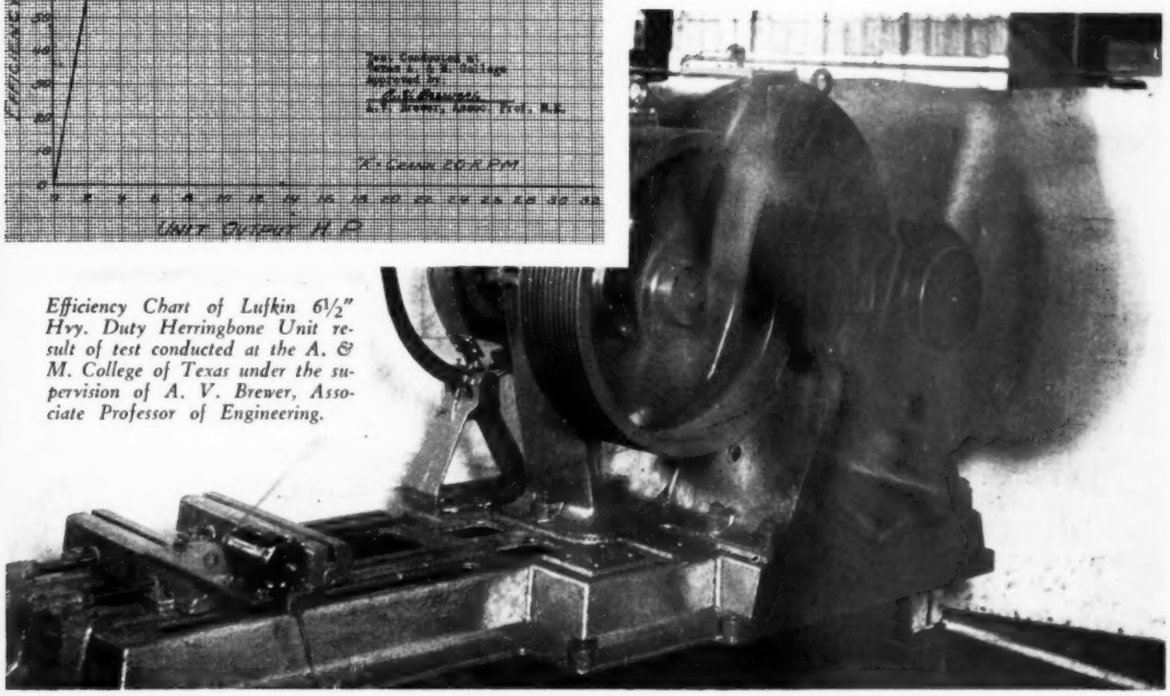
COMPARATIVE DATA	*Average of Ten Runs*	
	Without	*With*
Throughput and Yields	*Floor Tubes*	*Floor Tubes*
Gas Oil Charge Bbls. per Run	17,260	20,894
Gas Oil Charge Bbls. per Stream Day	642	896
Gasoline Bbls. per Run	11,006	13,210
Gasoline Per Cent Produced	63.7	63.2
Operation Conditions		
Reaction Chamber Pressure	700	700
Oil Inlet Temperature	585	585
Preheater Outlet Temperature	630	625
Convection Outlet Temperature	800	685
Floor Tube Outlet Temperature	.....	780
Temperature to Radiant Section	800	815
Transfer Temperature	875	885
Furnace Convection	1,570	1,500
Furnace Radiant	1,270	1,280
Cleaning Time Hours	22.8	23.5
Stream Time	645.2	559.5

No friction here



Efficiency Chart of Lufkin 6½" Hvy. Duty Herringbone Unit result of test conducted at the A. & M. College of Texas under the supervision of A. V. Brewer, Associate Professor of Engineering.

Unretouched photograph of Lufkin 6½" Hvy. Duty Herringbone Unit driven at regular speed of 22 strokes per minute by ½-H. P. motor. A Lufkin exhibit at the recent A. P. I. meeting.



With Ease A-Plenty — This Half-Horse Power Motor Propels Heavy Duty Lufkin Unit at Regular Pumping Speed

LUFKIN-HYATT-equipped—friction-free, Sykes-Herringbone Units are 98.9 to 99.44 per cent efficient as will be noted on the Efficiency Chart prepared under test in the laboratory of the A. & M. College of Texas. Such an attained efficiency, coupled with the highest degree of workmanship and of materials conforming to our own specifications assures the user long, efficient life and economy in operating and maintenance costs.

Without obligation, Lufkin engineers will gladly recommend the correct Lufkin installation for your lease.—Request this cost-free service TODAY!

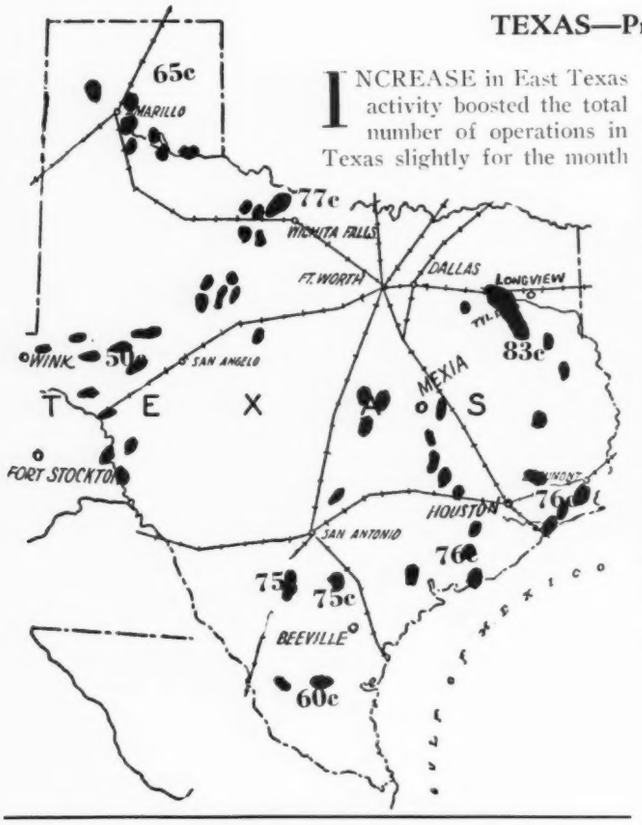
LUFKIN FOUNDRY & MACHINE CO., • • Lufkin, Texas

BRANCH OFFICES AND WAREHOUSES: Houston, Tulsa, Los Angeles, New York, Odessa, Eldorado, Seminole. EAST TEXAS HEADQUARTERS: Henderson, Texas, Crim Crest Hill, P. O. Box 516—Phone 142.

LUFKIN UNITS

Latest Activities *in the* Oil Fields*

TEXAS—Production, 1930—290,720,000 Barrels



INCREASE in East Texas activity boosted the total number of operations in Texas slightly for the month of October, when 879 tests were carried on drilling reports and 298 tests listed as rigs. Permits and completions also increased, there being 819 of the former and 590 completions. East Texas accounts for at least three-fourths of the state's activity and no decline in its operations is anticipated before sometime next year. The intensity of East Texas development is best shown by the mounting number of completions, of which there are expected to be 3,500 by the first of the year—or just one year from the start of important production discovery.

Following is a review of the active areas:

	POOLS			
	East Texas	Panhandle	Van	Refugio
Number of Permits	639	15	1	0
October Completions	458	8	1	2
Number of Rigs	164	15	0	0
Number Drilling Wells	698	29	20	3
Gravity of Oil	40	36	36	26
Depth of Production	3600	2900	2600	6500
Type of Tools Used	Rotary	Rotary	Rotary	Rotary
Number of Casing Strings	2	2	2	2

CALIFORNIA

Production, 1930—228,612,000 Barrels

A total of ten tests were completed in California during October, during which time 23 new locations were staked. The state had 18 rigs and 182 drilling wells at the close of the month.

No new field developments of importance have been made in the state recently, and the general condition of the industry may be termed as a waiting one.

Following is a survey of activities:

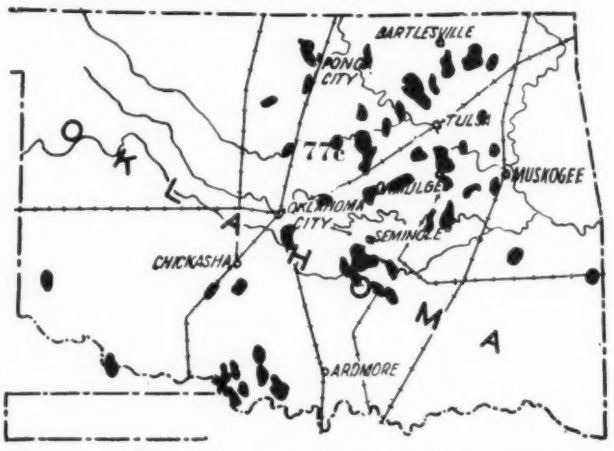
	POOLS			
	Playa Del Rey	Long Beach	Kettleman Hills	Ventura
Number of Permits	0	3	4	0
October Completions	1	5	0	1
Number of Rigs	1	1	2	1
Number Drilling Wells	3	5	8	9
Gravity of Oil	23	26	60	36
Depth of Production	6000	7000	8300	7800
Type of Tools Used	Rotary	Rotary	Rotary	Rotary

*All statistics as of November 1st.

● Denotes oil and gas fields.

OKLAHOMA

Production, 1930—214,425,000 Barrels

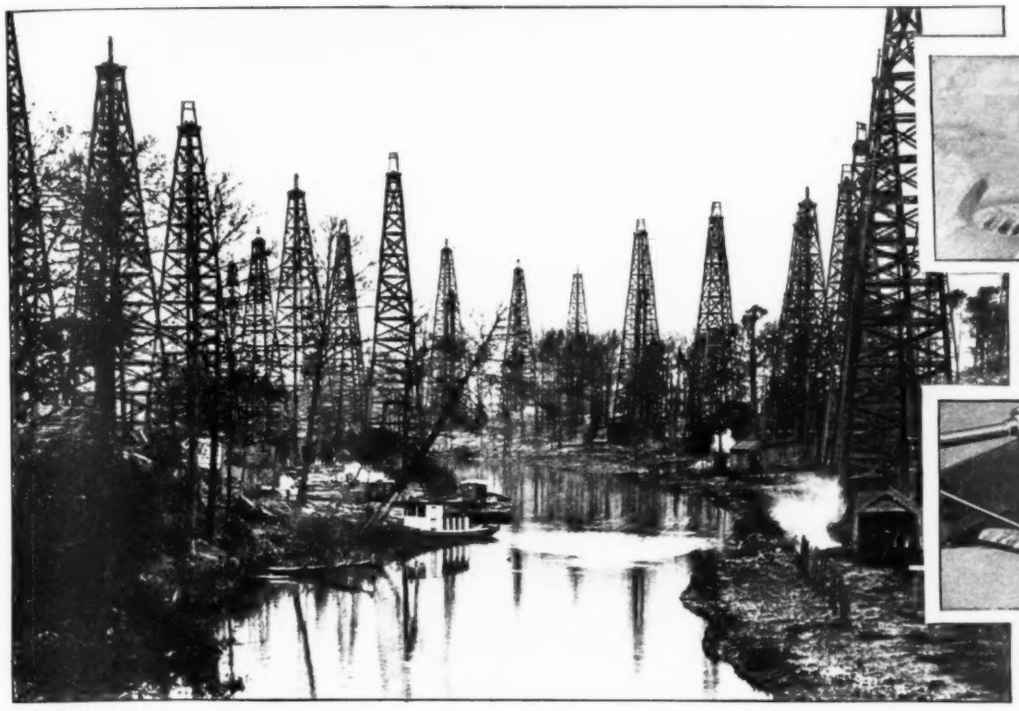


Interest in Oklahoma is centered around the deepest test ever drilled in the United States, Mid-Kansas Oil & Gas Company and Ramsey Petroleum Corporation's No. 6 Preston-Culp at Cement, which has a depth of 10,079 feet (October 29th).

A tabulated summary of the state's activity and that in the Oklahoma City pool follows:

	Entire State	Oklahoma City
Number of Permits	52	12
October Completions	46	13
Number of Rigs	39	14
Number Drilling Wells	73	20
Gravity of Oil	36 (average)	39
Depth of Production	Varies	6400
Type of Tool Used	Cab.-Rot.	Rotary
Number of Casing Strings	Varies	3

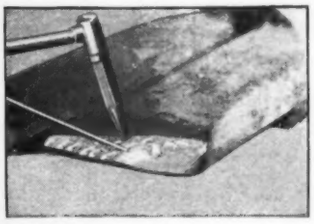
Figures on maps indicate average prices of crude oil per bbl.



E. GALLOWAY

HAYSTELLITE

Small pieces of Haystellite, the cast Tungsten-Carbide diamond substitute, welded in place.



Surfacing a Haystellite hard-set bit with Haystellite-Composite Rod (patent pending).

Red-Hardness Means Economy You Can Count Upon

IF only one fishtail bit set with Haystellite and faced with Haystellite-Composite Rod drilled 400 feet through shale, sand and limestone, and was only 1/8 in. out of gauge when pulled, the record would be interesting merely as a freak. But when bits protected with Haynes Stellite products equal and surpass this footage every day, oil men are interested because these results indicate maximum footage at minimum cost.

Haystellite is a cast tungsten-carbide alloy which combines great hardness with toughness sufficient to resist the impact of the drilling operation. Haystellite-Composite Rod is a combination of crushed Haystellite and a tough steel binder. These wear resisting products are easily applied by oxy-acetylene welding. The crushed Haystellite possesses the same excellent physical properties as the larger sizes of Haystellite and is uniformly distributed throughout the rod. This results in even distribution of the Haystellite on the cutting edges of the drilling tools.

The combination of uniform sizes of Haystellite and a subsequent facing of Haystellite-Composite Rod is the last word in hard facing oil well drilling tools.

If you are interested in reducing your drilling costs, write today for further information.

HAYNES STELLITE COMPANY

Unit of Union Carbide and Carbon Corporation

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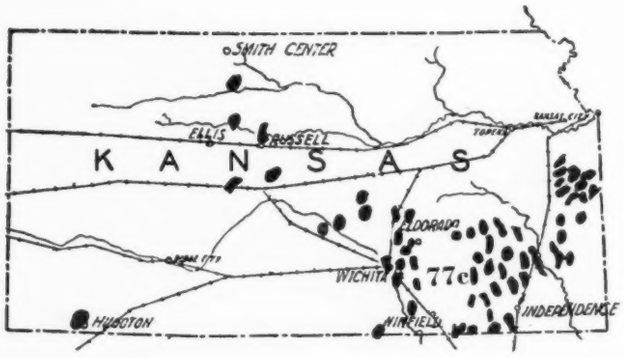
CHICAGO CLEVELAND HOUSTON DETROIT LOS ANGELES NEW YORK SAN FRANCISCO TULSA

General Offices and Works—Kokomo, Indiana

Haynes Stellite alloys are available also at all of the 42 apparatus shipping points of The Linde Air Products Company

KANSAS—Production, 1930—41,745,000 Barrels



There were 59 drilling wells and 38 rigs in Kansas the last of October, during which month 26 tests were completed and 27 new locations were staked. Both rotary and cable tools are used in this state, with the latter type predominating.

Following is a summary of the active fields:

POOLS

	Sedgwick County	McPherson County	Hugoton Field
Number of Permits	0	9	0
October Completions	3	11	3
Number of Rigs	2	15	0
Number Drilling Wells	0	27	1
Gravity of Oil	39	37	Gas
Depth of Production	2900-3500	2900-3400	2700
Number of Casing Strings	2	2	2

ARKANSAS

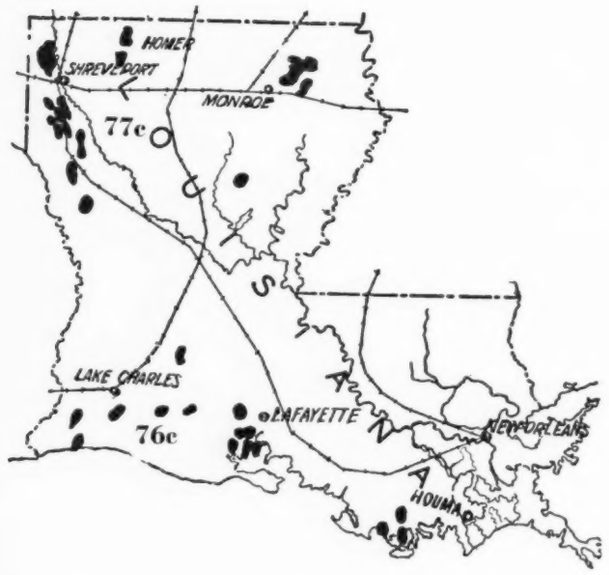
Production, 1930—19,680,000 Barrels

There were only two completions and one new permit recorded in Arkansas during October, while only six rigs and 23 tests were active.

Drilling contractors used rotary tools for practically all their drilling operations because of frequent gas pressures and soft, cavey formations.

LOUISIANA

Production, 1930—23,150,000 Barrels



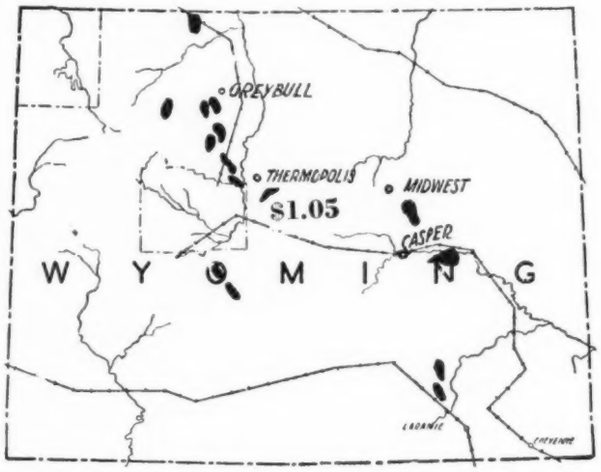
Sixteen permits, 29 completions, 14 rigs and 81 drilling tests made up Louisiana oil field activity during October. Rotary tools are operated in both the Gulf Coast and Northern regions. Formations are generally soft and cavey with high gas pressures.

Mississippi, adjoining to the east, had four completions, 10 rigs and 20 drilling wells on its activity report.

WYOMING

Production, 1930—11,177,000 Barrels

Wyoming had seven completions, 11 rigs and 73 drilling tests last month. Most of the state's operations are drilled with cable tools.

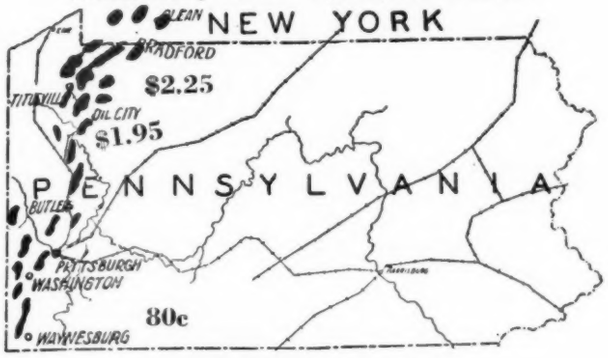


● Denotes oil and gas fields.

Figures on maps indicate average prices of crude oil per bbl.

NEW YORK

Production, 1930—3,825,000 Barrels



PENNSYLVANIA

Production, 1930—12,810,000 Barrels

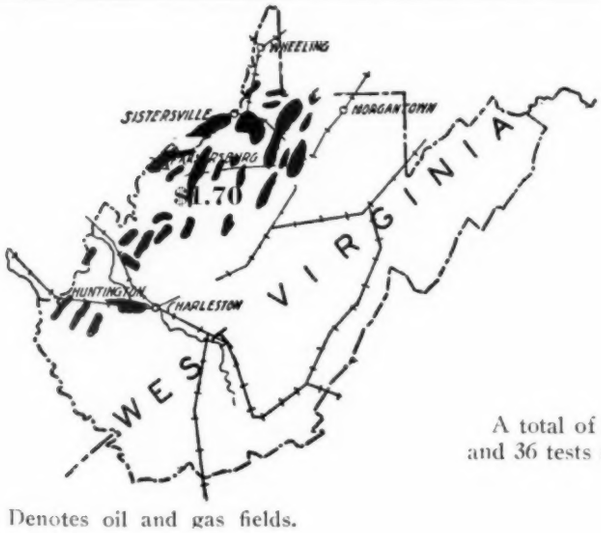
A total of 54 wells were completed in New York and Pennsylvania, of which 37 were in the latter state. The two states had 20 rigs and 88 drilling tests at the end of the month, with the Tioga-Wayne area leading in activity.

ILLINOIS

Production, 1930—5,695,000 Barrels

Activity in this state continues to remain practically constant, there being two completions, one rig and 15 drilling wells carried on operating reports during the month of October.

Standard tools are used by operators for making all holes in the district, where producing horizons are found at shallow depths and generally offer no difficult drilling problems.



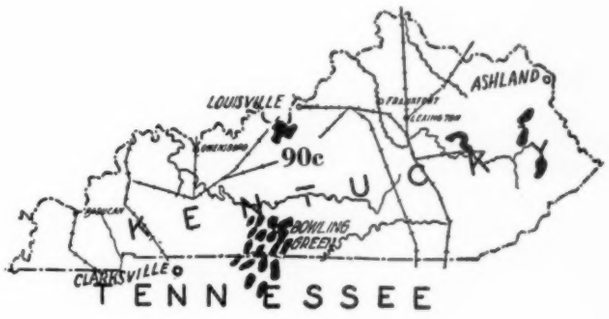
● Denotes oil and gas fields.

KENTUCKY

Production, 1930—7,300,000 Barrels

Field reports showed 30 completions, 10 rigs and 75 drilling tests for October in Kentucky. In Tennessee there were no completions and no rigs with 14 drilling tests.

Drilling in both states is carried on with standard tools.



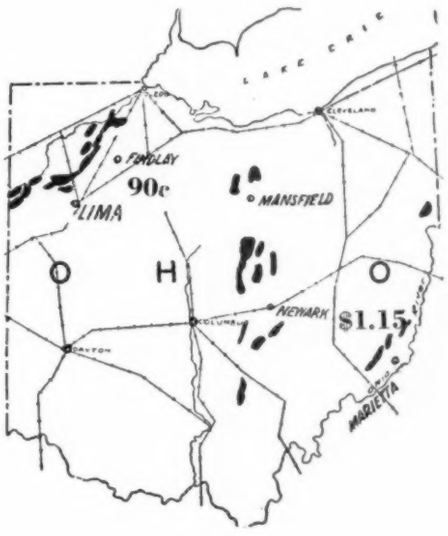
TENNESSEE

Production, 1930—20,000 Barrels

OHIO

Production, 1930—6,525,000 Barrels

Ohio had 67 completions, 36 rigs and 128 drilling wells during the month of October. Activity continues to be most in the central area, where 24 rigs and 91 drilling tests are located. All wells are drilled with cable tools.



WEST VIRGINIA

Production, 1930—5,100,000 Barrels

A total of 22 tests were finished in West Virginia last month. Nine rigs and 36 tests are drilling in the state, all operating with cable tools.

Figures on maps indicate average prices of crude oil per bbl.

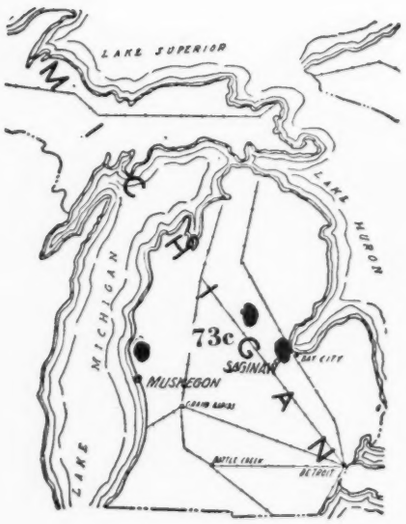
NEW MEXICO

Production, 1930—10,235,000 Barrels

Last month there were only four tests completed in the state of New Mexico. Other activity included six rigs and 43 drilling tests. Most of the activity in the state is near the Hobbs pool, where rotary type drilling tools are in use; however, in other parts of the state standard tools are used for making hole. The decline in Hobbs activity has been responsible for the drop in New Mexico's activity.

MICHIGAN

Production, 1930—3,525,000 Barrels

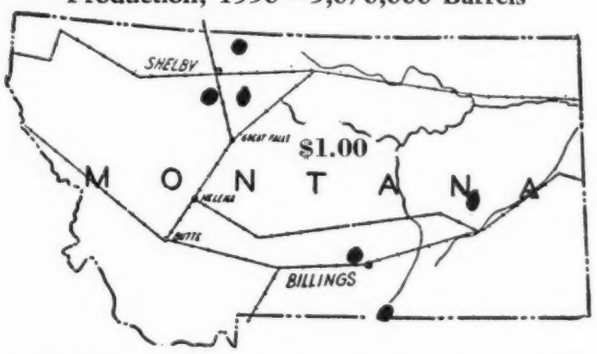


Activity in Michigan during the month of October was comprised of 11 completions, 71 rigs and 99 drilling tests.

Practically all the wells in this state are drilled with cable type tools and rigs, only in a few instances are rotary tools in use.

MONTANA

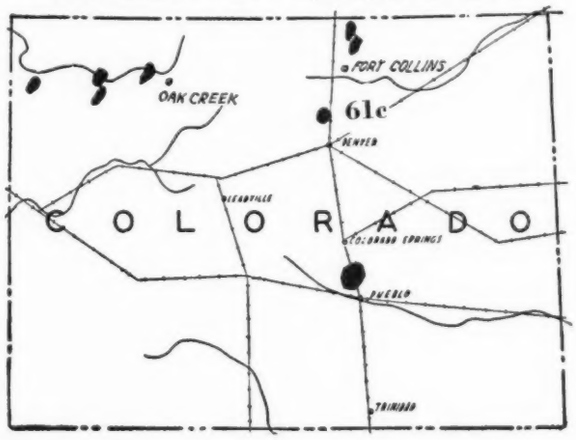
Production, 1930—3,070,000 Barrels



Nine completions were made in Montana during October, while the state had 17 rigs and 69 drilling tests.

COLORADO

Production, 1930—1,644,000 Barrels



There was but one completion in Colorado last month, when the state had 12 rigs and 80 drilling tests. Increase in activity is due to the new Greasewood or Platte Valley field. Rotary tools are used for drilling in this field.

INDIANA

Production, 1930—1,000,000 Barrels

A total of nine tests were completed in Indiana during October. The state had six rigs and 53 drilling tests.

Shallow producing horizons in the region are easily and quickly reached, with cable tools the most common means of making hole.

● Denotes oil and gas fields.

Figures on maps indicate average prices of crude oil per bbl.

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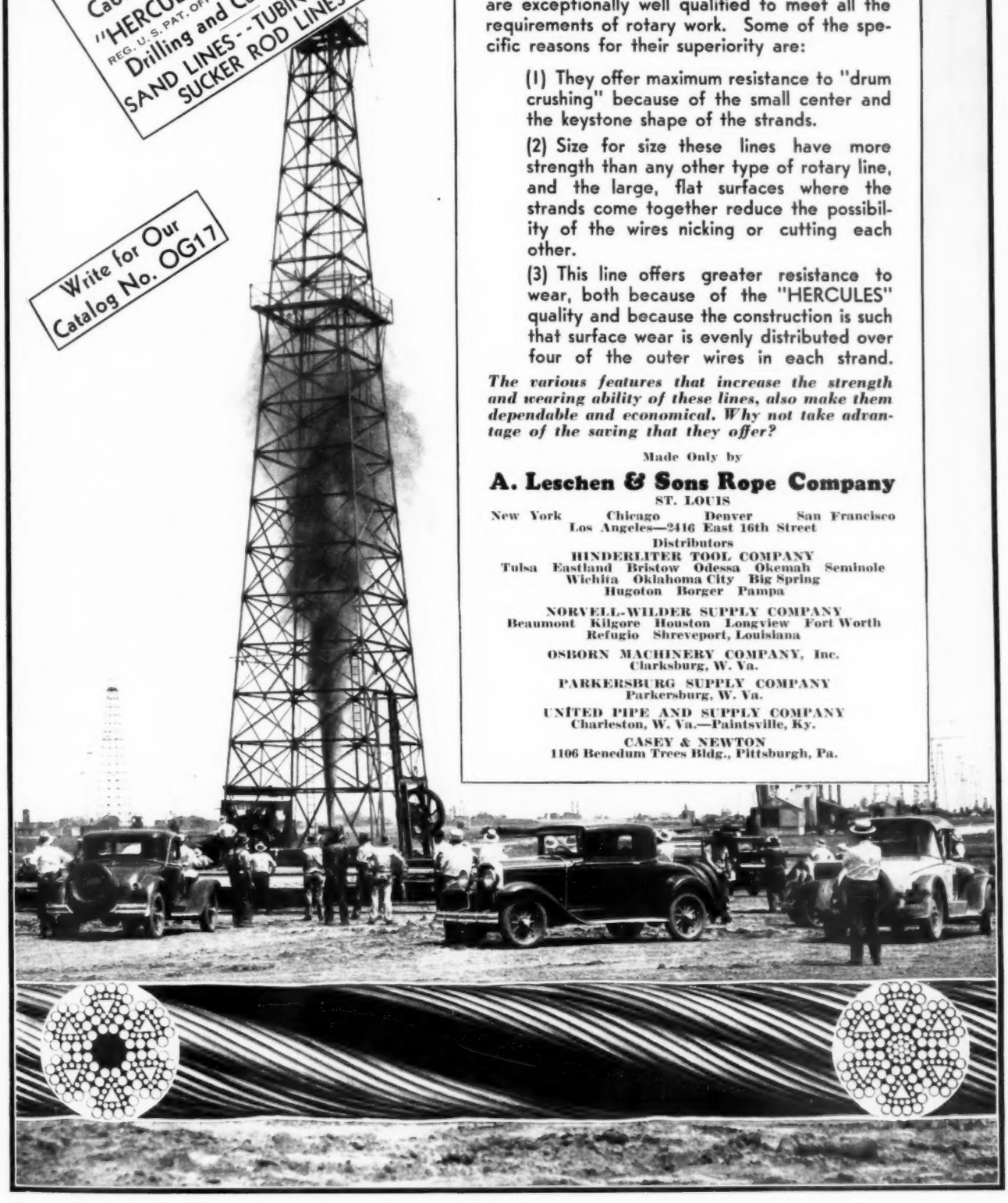


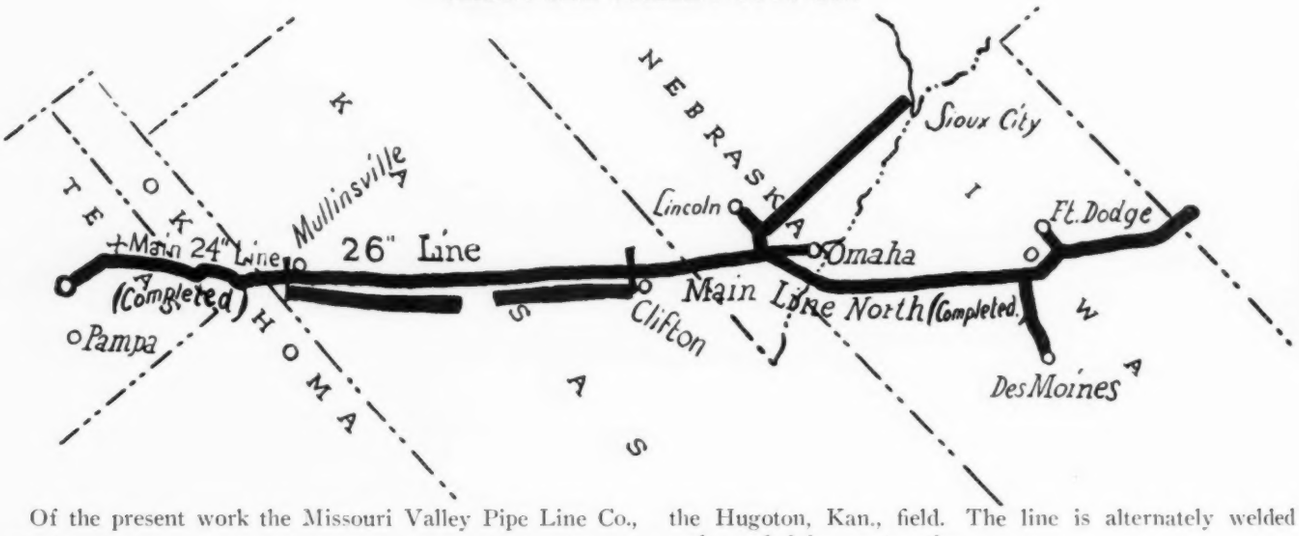
Progress of Major Pipe Line Work

By J. H. DAMERON

AS 1931 draws to a close most of the current year's pipe line construction programs are nearing the finish line. At the same time plans are moving forward for next year's expansion work. Most of the builders of large gas transmission systems have a great deal of extension work and lateral line construction mapped out for 1932. On top of this attempts are being made to revive several major gas line projects involving many hundred miles of line. Existing gasoline systems are reported considering major loop work and station expansion for next year and other gasoline lines are reported as being under consideration.

Oil line expansion is expected to go forward at a fair pace and in this connection the Stanolind Pipe Line Co. has already started on a major expansion program of looping and increasing station capacity. For the past two years maintenance and repair work on trunk lines has been held down to a minimum but next year's program will include work that cannot be postponed.

MISSOURI VALLEY P. L. CO.

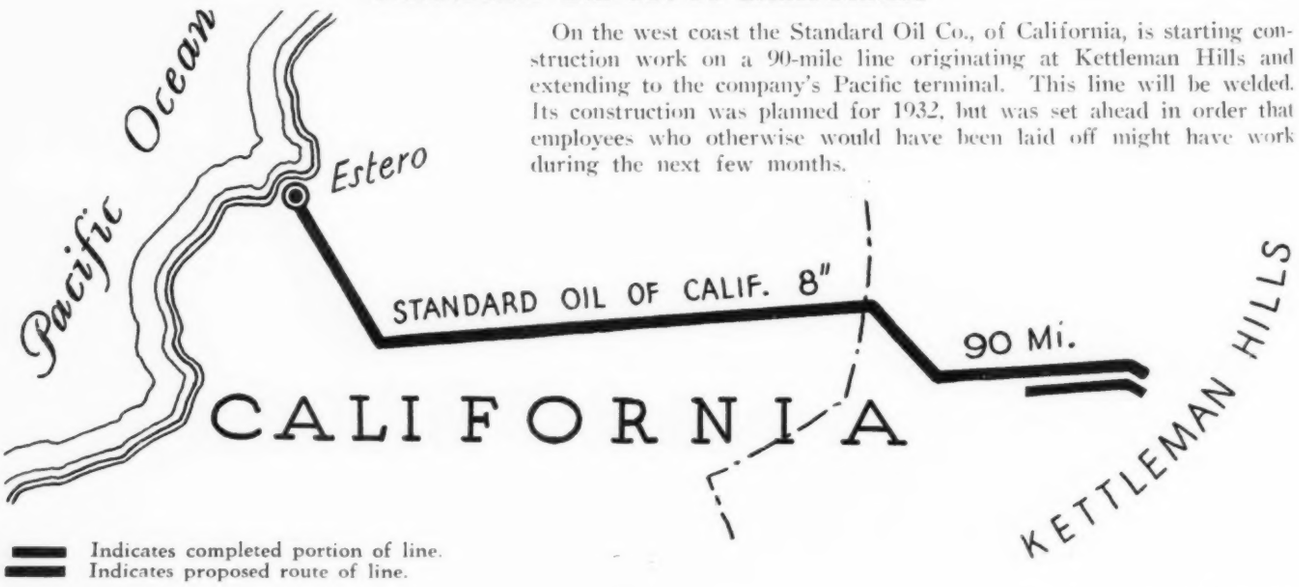


Of the present work the Missouri Valley Pipe Line Co., Omaha, Nebr., is nearing completion on its section of 26-inch line in Kansas. This section, approximately 200 miles long, is being built by Smith Bros., Dallas, Texas, contractors. It closes in a gap on the company's 24-inch main line coming out of the Texas Panhandle and from the Hugoton, Kan., field. The line is alternately welded and coupled in construction.

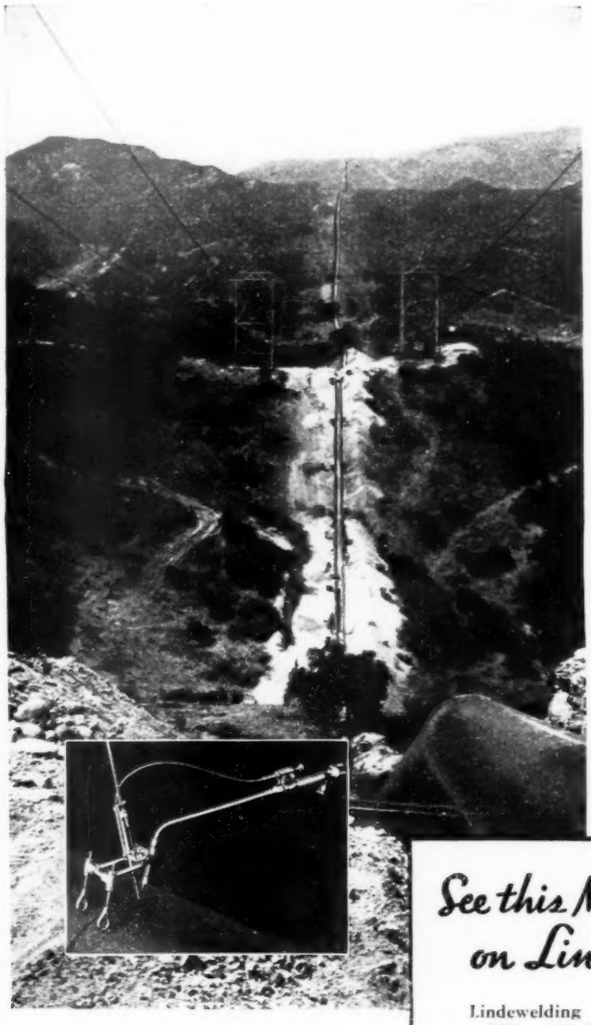
In addition the transmission company is building a 90-mile 14-inch extension into Sioux Falls. The contract was awarded to the Fredell Construction Co. Truman-Smith Construction Co., is building a 65-mile 16-inch extension from the Iowa terminal on north into Minnesota.

STANDARD OIL CO. OF CALIFORNIA

On the west coast the Standard Oil Co., of California, is starting construction work on a 90-mile line originating at Kettleman Hills and extending to the company's Pacific terminal. This line will be welded. Its construction was planned for 1932, but was set ahead in order that employees who otherwise would have been laid off might have work during the next few months.



LINDEWELDING



A Lindewelded 26-in. section of a 210-mile gas line in California.

. . .

Inset shows the Lindewelder, a special appliance which further increases the speed of Lindewelding.

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Procedure Controls for this new method of oxy-acetylene welding are available to all Linde customers through Linde Process Service. Any Linde District Office will be glad to give you complete information.

See this Motion Picture on Lindewelding

Lindewelding technique differs from oxwelding technique in that it employs a special rod, a special flame adjustment, and the "back-hand" method of blowpipe manipulation. The actual steps in making a Lindewelded joint are shown in our motion picture, "The Lindeweld Process for Pipe Line Construction." This picture will be loaned without charge to pipe line officials and welding or engineering societies. It is furnished in 16 mm. and 35 mm. safety film and can be obtained by writing to any Linde District Office.

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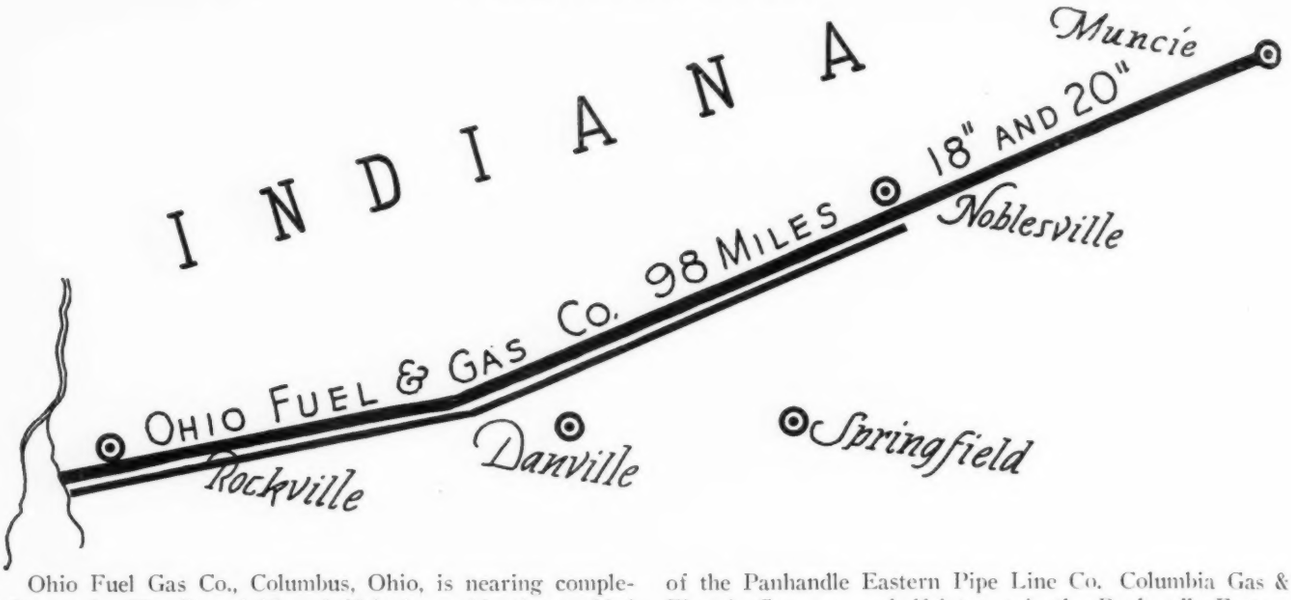
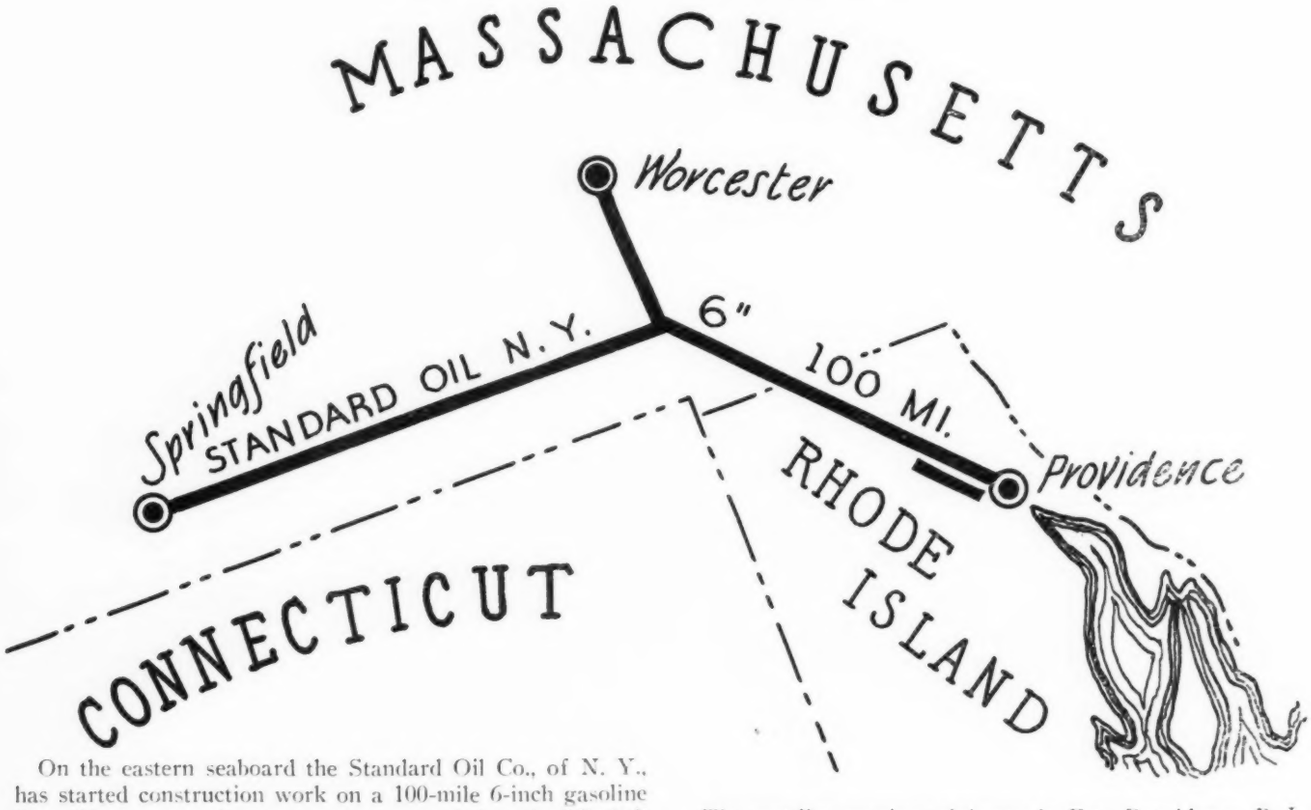


Ohio Fuel Gas Co., Columbus, Ohio, is nearing completion on its 98 miles of 18 and 20-inch combination welded and coupled line from a point near Rockville, Ind., to Muncie, Ind. The company is building the line with its own construction crews. The line ties into the main line of the Panhandle Eastern Pipe Line Co. Columbia Gas & Electric Co., owns a half interest in the Panhandle Eastern and Ohio Fuel Gas Co. is also a Columbia subsidiary and the project to Muncie is the connecting link between the two systems.

STANDARD OIL CO. OF NEW YORK



On the eastern seaboard the Standard Oil Co., of N. Y., has started construction work on a 100-mile 6-inch gasoline line. The construction contract was awarded to the Mitchell Stewart Co., of Dallas and W. A. Sniffen, of the Magnolia Pipe Line Co., Dallas, will be in charge of the work. The line will be welded.

The gasoline carrier originates in East Providence, R. I., at terminal facilities. The refined products will be pumped to Springfield, Mass., and a lateral line will extend to Worcester, Mass.

Indicates completed portion of line.
Indicates proposed route of line.

PIPE LINES UNDER CONSTRUCTION AND CONTEMPLATED

Type Line	Company Name	Headquarters	Point of Origin	Terminal	Size Pipe	Length in Miles	Remarks
Ga.L.	Great Lakes P. L. Co	Kansas City, Kan	Oklahoma	Great Lakes Region	4-6 & 8"		Plan to loop line and increase station capacity or to build booster stations.
G. L.	Columbia Gas & Electric Co	New York, N. Y.		Detroit, Mich.	20"		Reported planning gas line to Detroit, Mich.
G. L.	Continental Construction Corp	Chicago, Ill.	Point in Illinois	Milwaukee, Wis.	20"	160	Making right of way survey and may build in winter.
G. L.	Iroquois Gas Co	Buffalo, N. Y.	Wayne Field	Buffalo	8"	60	Under construction.
G. L.	International Utilities Corp	New York, N. Y.	Alberta, Can.	Vancouver, B. C.	20"	500	Plan to build $30,000,000 gas line. D. E. Lamb, Portland, Ore., western representative.
G. L.	Jerome Drumheller	Spokane, Wash.	Cut Bank, Wyo.	Seattle, Wash.	20"	500	Proposed.
G. L.	Kansas Communities Gas Co	Chanute, Kan.	Local Field	Chanute		15	Plan short line and field station.
G. L.	Kansas P. L. & Gas Co	Salina, Kan.	Grantville, Kan.	Atchison, Kan.		40	Construction to start soon.
G. L.	Kansas P. L. & Gas Co	Salina, Kan.	Keystone, Nebr.	Freeman, Mo.	10 & 12"	450	Reconditions 450 miles of Stanolind Wyoming line. Work about complete.
G. L.	Lycoming Natural Gas Corp	New York, N. Y.	Tioga Field	Syracuse	20"	100	Shut down.
G. L.	Missouri Valley P. L. Co	Omaha, Nebr.	Point in Minn.	Minneapolis, Minn.			Proposed.
G. L.	Missouri-Kansas P. L. Co	Chicago, Ill.	Russellville, Ky.	Nashville, Tenn.		50	Proposed.
O. L.	National Transit Co		Western Penn.	Eastern Seaboard			Repairing old line and installing 12 new horizontal duplex pumps.
G. L.	Ohio Fuel Gas Co	Columbus, Ohio	Point in Indiana	Muncie, Ind.	18 & 20"	98	Nearing completion.
G. L.	Pacific Gas & Electric Co	San Francisco, Cal.					Plan to start $2,000,000 expansion program.
G. L.	Public Service Corp	Jackson, Miss.	Jackson	Hattiesburg	8"	90	Nearing completion—welded line.
Ga.L.	Phillips P. L. Co	Bartlesville, Okla.					Building booster station on St. Louis line at Sharp, Kan.
O. L.	Phillips P. L. Co	Bartlesville, Okla.					Increasing station capacity on K. C., Mo., line.
Ga.L.	Sun P. L. Co.	Philadelphia, Penn.	Point in N. Y.	Lake Ontario	6"	45	Extending main line to deep water teminal.
G. L.	Simms Oil & Gas Co	Bellecenter, Ohio	Bellecenter	Ridgeway, Ohio	6"	33	Proposed.
O. L.	Stanolind P. L. Co	Tulsa, Okla.	Oklahoma	Chicago, Ill.	8-10 & 12"		Constructing 340 miles of loop work and adding additional pumping equipment to increase capacity to about 15,000 barrels per day.
O. L.	Texas P. L. Co	Houston, Tex.	Markham Field	Trunk Line	4"	21	Letting contracts.
G. L.	United Public Service Corp	Houston, Tex.					Building 100 mile extension in South Louisiana.
G. L.	Wasatch Gas Co	Ogden, Utah					Plan to extend main line in Idaho and Utah. Cost $3,000,000.

The Month's Activities *in* Refining*

By F. R. STALEY

MANY refiners are planning the installation of reforming units in order to increase the octane number of their motor fuels. The Standard Oil Co. of Kansas is installing new cracking equipment at its Neodesha refinery.

The Gulf Refining Co. is building several new units in its Toledo refinery.

The Arthur G. McKee Co. will build a rerun pipe still and a Dubbs cracking unit for the Italiana Combustibili, S. A. at Porto Marghera, Italy.

The A. O. Smith Corp. has just completed the largest cracking unit ever built. It is to be assembled in the field at the West Tulsa refinery of the Mid-Continent Petroleum Corp.

The annual report of Committee D-2 on Petroleum Products and Lubricants has recently been issued by the American Society for Testing Materials. The publication contains 33 standard methods and 14 tentative test methods for petroleum products. The society has also published a bulletin on The Economic Significance of Specifications for Materials. This contains a discussion on Motor Oils by H. C. Mougey, General Motors Corp.

The U. S. Bureau of Mines Report of Investigations 3143, recently released, treats on the Production of Motor Fuels from Natural Gas.

Fuel technologists from many countries will attend the Third International Conference on Bituminous Coal in Pittsburgh, Pa., Nov. 16-20. About 100 papers will be presented.

Natural Gasoline

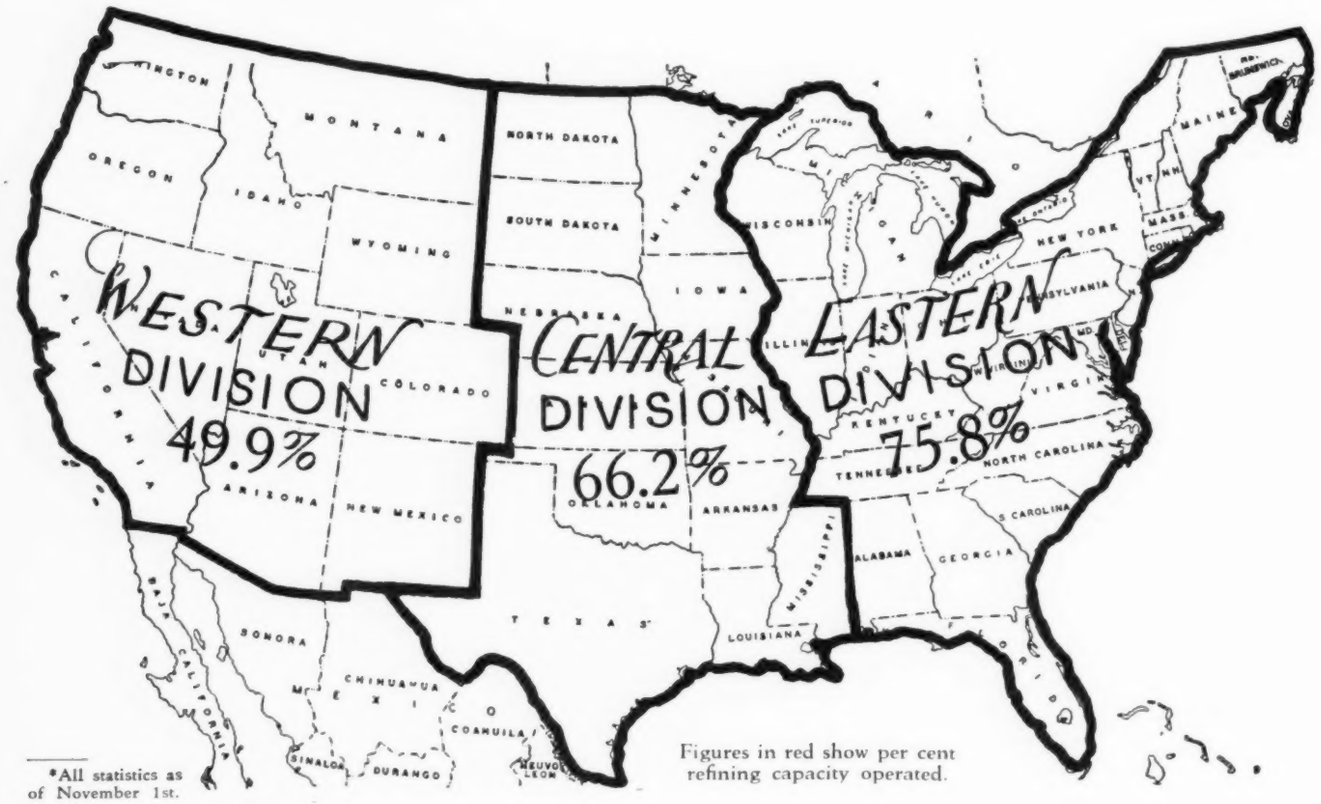
The Humble Oil & Refining Co. recently completed two compression plants in the East Texas field. These are the first gasoline plants to be built in this area. They are primarily gas conservation plants. The gas will be compressed in three stages and put back into the wells.

The Southern Pacific Railroad will use compressed natural gas to illuminate about 300 cars running out of Los Angeles, replacing Pintsch gas.

France is reported to be the largest European buyer of California natural gasoline.

The Standard Oil Co. of California is preparing butane and propane for use in refrigerating plants.

A paper on Distribution and Use of Propane and Butane was presented by H. W. Wickstrom at the October meeting of the California Gasoline Association in Los Angeles.



Figures in red show per cent refining capacity operated.

*All statistics as of November 1st.

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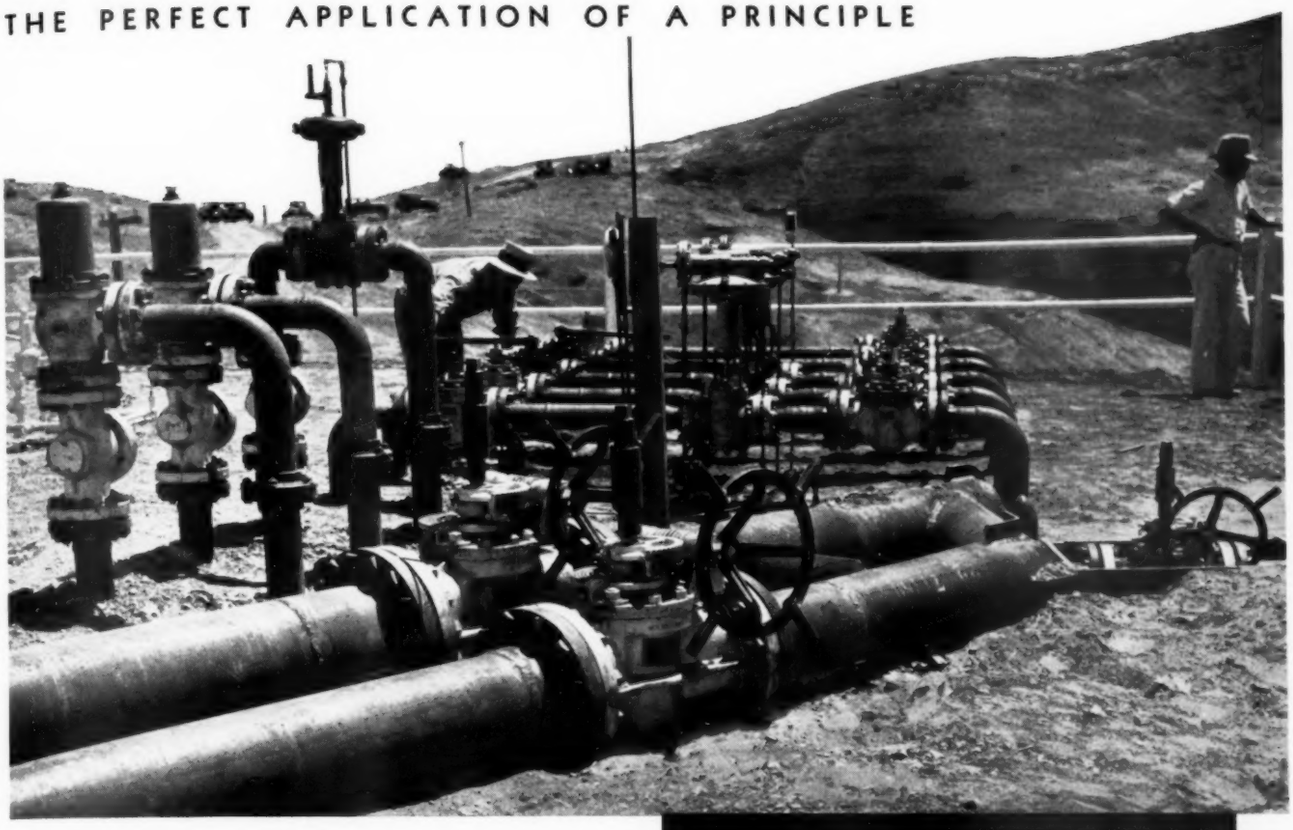

ILLUSTRATION shows regulators from gas traps in a Kettleman Hills plant equipped with Nordstrom "Venturi" Valves. This assures perfect valve control because the "Sealdport" principle of lubrication prevents gas leaking internally or externally. Ask for new catalog No. 8.

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Buenos Aires, Argentine, - General Electric, Soc. Anon., Victoria 618 Esq. Peru.

Despite Obstacles WORLD'S LONGEST

THE feat of running and cementing the longest string of casing in the world, 9,777 feet and three inches of 6⅝-inch pipe, despite encountering a baffling problem in lost mud circulation, forcefully demonstrates the rapid development of deep-well drilling technique during the past year, when three test wells have penetrated beyond 10,000 feet. The feat was accomplished on the Mid-Kansas Oil & Gas Company and Ramsey Petroleum Corporation's Preston-Culp No. 6 test, near Cement, Caddo County, Oklahoma, which is now the deepest hole in the United States and the second deepest in the world.

The establishment of a new casing record adds to deep drilling history another chapter of value as reference in the completion of future deep wells. Outstanding features of this job were: (1) The only difficulty experienced in the entire job was in getting circulation after running the casing. Good circulation is vitally important in setting a long casing string. (2) The ease with which this long casing string was run demonstrated that, by virtue of the "floating in" method, casing strings of far greater length can be run successfully in good holes, and (3) cementing operations can be performed at depths of 10,000 feet.

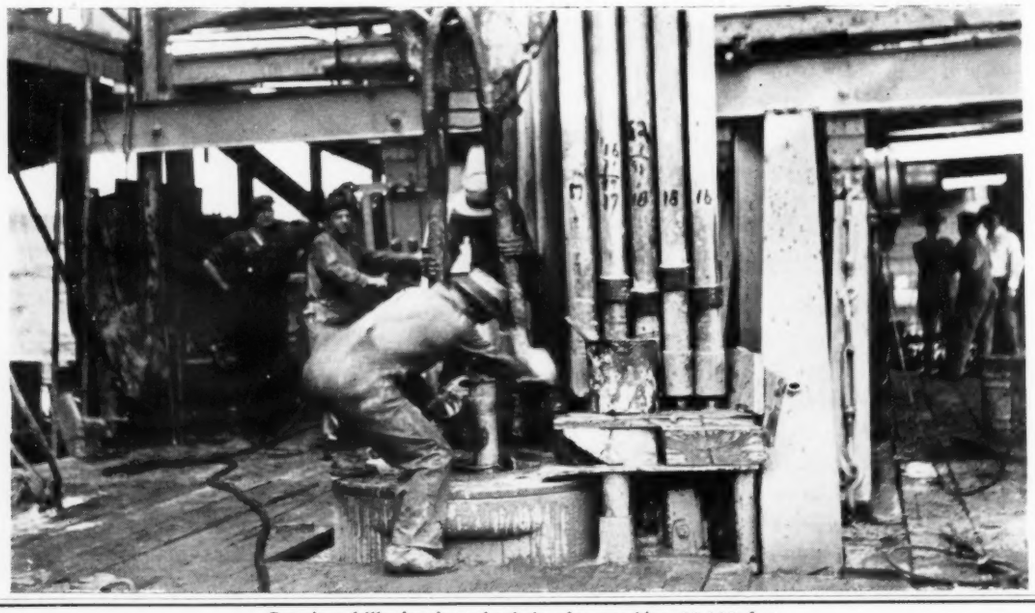
The failure to get circulation immediately was due probably to two or more combined factors, namely: (1) The small annular space between the pipe and wall of the hole, (2) porous formations, (3) congealing of rotary mud at bottom of hole due to high compression and settling while running casing, and (4) a bridged hole.

In attempting to establish circulation after the casing was run, practically all the mud in the three big slush pits was pumped into the hole, indicating that the fluid was being taken by the formations. From 5,515 feet down, an 8⅛-inch bit had been used, making a hole of about nine inches diameter. As the casing couplings are greater than seven inches in diameter, this left a relatively small annular space for mud circulation and meant that a high pressure would be required to circulate the mud up behind the casing. This required pressure might not have been high enough for circulation but still great enough to squeeze the water from the mud into the formation. This theory is supported by the fact that circulation could be obtained by reversing the flow but not by circulating down the six-inch casing, and also that a pressure of several hundred pounds less was required with reversed circulation.

Slight difficulty was experienced around 7,100 feet in running the casing and some of those present were of the opinion that the hole had probably bridged at this point; however, when circulation was reversed some returns were obtained, indicating that the bridge, if present, had been removed. The high bottom-hole temperature and the fact that the heavy rotary mud had been allowed to settle 48 hours before and during the time the casing was run may have caused the mud in the bottom of the hole to settle and congeal—a condition that would materially increase the difficulty of restoring circulation and getting returns.

It required considerable ingenuity and perseverance to overcome the baffling condition that arose when circulation could not be established. Mud injection for circulation purposes was commenced and maintained at a well-head pressure of from 1,100 to 1,400 pounds, rising at times to 1,500 pounds, for approximately 18 hours, when the reverse method of circulation was tried—that is, pumping down between the 9-inch and 6-inch casing. By reversing circulation it resulted in obtaining returns between the 9-inch and 12-inch casing and a small return up the 6-inch. After changing the circulation back to the regular method of down the 6-inch casing, the small stream of returns was lost again and could not be regained except by reversing the flow. Good returns were secured by reverse circulation after the cement shoe and float collars had been knocked out — these were not necessary for circulating operations.

During the 18 hours of circulation immediately following the running of casing the pressure was built up alternately by the mud hogs and the cement truck pumps. The pressure during this time fluctuated between 1,100 and



Running drill pipe into the hole after reaching 10,000 feet.

CASING STRING *Safely Landed*

By WARREN L. BAKER

1,500 pounds repeatedly, which, with the irregular motion and laboring of the pumps, made it seem as if a series of small bridges of compressed mud or clay at the bottom of the hole was being broken through.

Considerable work was necessary in changing connections before circulation could be reversed, as a short joint of 12-inch pipe projecting from a head in the cellar to the rig floor had to be removed so mud pump connections could be made and the 9-inch packed off. All the 6-inch casing had been lowered through this short joint of 12-inch. The McEvoy head in the cellar was so constructed that a set of 6⅝-inch slips could be placed in it to support the weight of the pipe. The weight of the pipe was lowered from the spider onto the McEvoy head, the 12-inch joint removed, and connections and packing installed for reversing the direction of flow.

Engineers hoped by reversing the circulation to be able to apply sufficient pressure on top of the bridge, which at that time was thought to be shutting off circulation, to knock it out. When returns came up the 12-inch surface string they indicated that the 9-inch casing had sprung a leak. Practically half the hole had been drilled through the 9-inch casing. The small returns through the 6-inch casing gave hope that circulation could be secured. It is probable that under reversed flow the circulation returns up the 6-inch string, which ordinarily would not be expected while the float valve was still in the casing, were due to compressed mud in the bottom having lodged in the cement float shoe valve, thereby holding it slightly open.

After the meager but encouraging results from reverse circulation, and then negative results from later prolonged circulation down the 6-inch, it was decided to pack off the leak in the 9-inch that was discovered by returns up the 12-inch with reverse circulation. This was done by cementing between the 9-inch and 12-inch strings. Before again attempting to restore circulation the cement float collars and shoe were knocked out with the bit so a larger volume of mud could be injected, and a Hercules 6-inch by 9-inch bradenhead installed for injection connections. Attempts to get circulation by the regular direction of flow were still unsuccessful, but returns were secured by reversing the flow and led to the decision to cement the 6-inch string from the outside (cementing from top, down the annular space between the 9-inch and 6-inch casings).

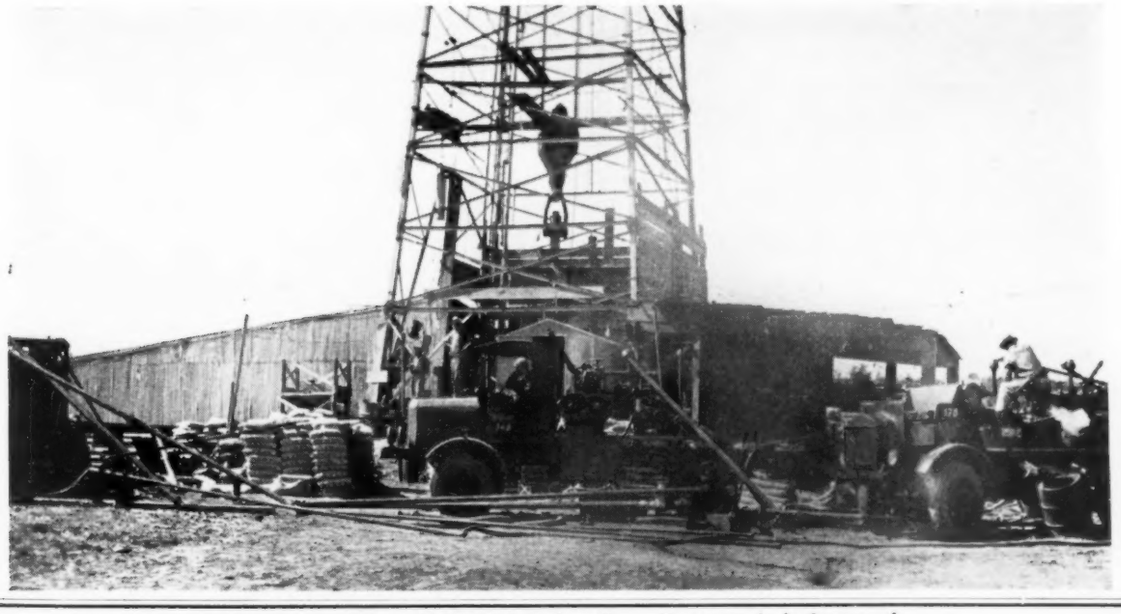
A total of 1,875 sacks of cement was mixed and placed between the 6-inch and 9-inch strings by the Halliburton Oil Well Cementing Company, which had four trucks at the well site and to this company considerable credit is due for their willing co-operation and aid. As soon as all the cement was pumped between the two casing strings it was forced downward by pressure from rotary mud pumped in on top of the cement.

At this time the well is shut down awaiting setting of the cement, when the drill will be lowered into the hole to determine if the cement came up into the 6-inch casing. If it did not, an attempt will be made to cement the bottom of the 6-inch casing through tubing.

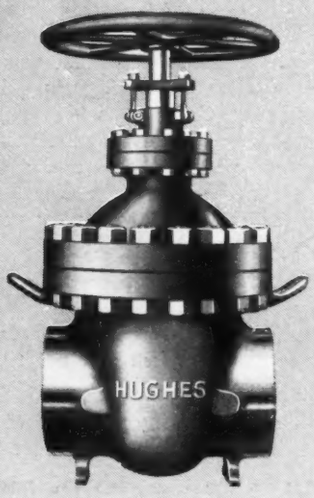
It will be exceedingly interesting to see the results from cementing behind the casing at so great a depth.

The bottom of the hole was estimated to have a temperature of from 180 to 200 degrees F. Because of the accelerating effect this high temperature would have on the setting of the cement and expansion of the pipe, it was decided to lower the bottom-hole temperature as much as possible by circulating ice-cooled mud. The day before running the casing, ice was dumped in the slush pits, cooling the mud to a temperature of 40 degrees F. By adding ice from time to time, the temperature was kept low. A total of 20 tons of ice was used in this manner.

The casing string is made up of 325 joints of 6⅝-inch O. D., 26 20-pound, 2,800-pound test, 10-thread, ⅜ taper, Youngstown seamless casing with an average tensile strength in excess of 100,000 pounds. The lower 5,600



General view of the well during circulation efforts. Cement trucks in foreground.



REMEMBER

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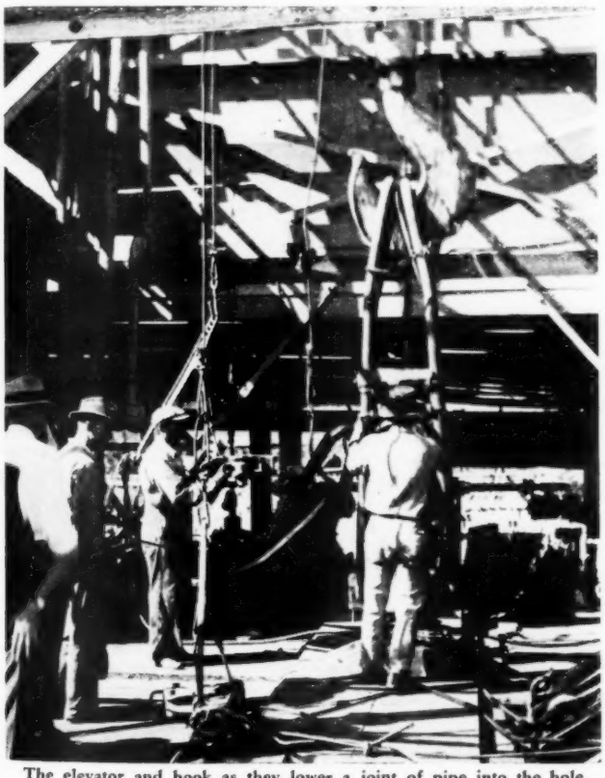
feet of casing has 8-inch couplings, while the remaining upper part of the string has 9-inch, long-thread couplings having about 38 effective threads. The total weight of the entire string is approximately 130 tons, which, although not the heaviest, is the longest string of casing yet run in a well.

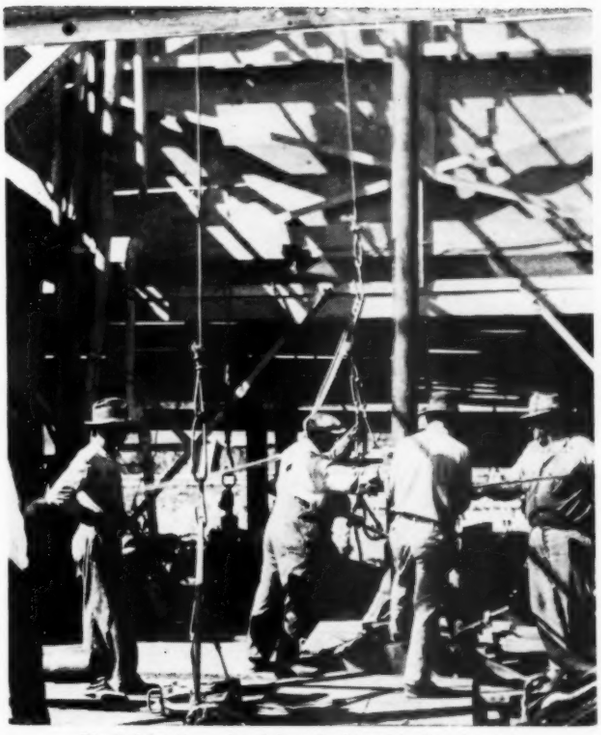
All the casing was floated into the hole. The first 14 joints were welded together with a Baker Oil Tool 6⅝-inch cement side hole float shoe welded on the bottom joint. Two float collars were placed above the casing shoe. One of these, made by the Bartlesville Supply Company, was constructed of special South American wood, while the top one was a Baker cement float collar.

The welding of the first 14 joints required two hours and about 18 hours additional time was needed to run the entire string in the hole. Extreme care was taken in handling the pipe, no effort being made to hurry the job. Considerable preliminary work was done in getting the casing ready. All joints of casing were carefully cleaned while stacked outside the rig, during which time the factory thread protectors were removed and the threads leaded. The cleaning operation consisted of steaming the casing and using a brush on the threads. The casing was gradually rolled along the casing rack toward the rig during these preliminary precautions. When carrying the casing from the rack to the rig floor by pipe truck the threads on the uncoupled end were protected by a heavy rubber band. Each joint of casing was started into the coupling by taking a few turns with hand tongs before spinning it slowly with the rope, and final tightening was done with Byron Jackson casing tongs operated by a jerk line.

Careful inspection was made of the manner the casing made up, so that no joints with galled or damaged threads would be run in the well. The inspection comprised watching the engine and jerk line action to judge the force required to tighten each joint of casing, the number of threads exposed after making-up was observed, and the amount of heat noted by testing the temperature of the coupling with the bare hand. Before taken onto the rig floor all joints of casing were tallied and, as these were lowered into the hole, they were checked off the tally list.



The elevator and hook as they lower a joint of pipe into the hole, preparatory to stabbing another joint.



Final tightening of a joint of pipe with the pipe tongs.

Considerable preparation was made at the rig before the casing was run. The rig floor was prepared by removing the rotary table and replacing it with a heavy steel spider and slips, which were supported on heavy timbers. The spider slips were operated by a long handle. A heavy-duty elevator was used, attached to a heavy, spring-type, Ideal 9-inch hook. The 122-foot Parkersburg derrick was reinforced and all other equipment inspected and prepared for the severe service ahead.

When the crew got ready to bring the drill pipe out of the hole preparatory to running casing, Aquagel was added to the circulating mud, which weighed from 11 to 11½ pounds per gallon, conditioning it so that gas in upper horizons would not interfere with setting of the cement and so that friction would be reduced and prevent the hole from caving badly. When the drill pipe was taken out of the hole it was broken at the joints and stacked outside the rig. Before thickening the mud the pits were cleaned and the mud carefully screened.

Mid-Kansas and Ramsey have been very successful on this well from the drilling standpoint. The only drilling trouble experienced outside of some very hard formations has been one small fishing job. The drill pipe, which previously had been used to drill several wells in the Oklahoma City field, twisted off after the well reached a depth below 10,000 feet. It broke near the top of the hole and only six hours of fishing with an American Iron & Machine Company overshot was required to recover the heavy string of drill pipe.

After the cement has set the well will be drilled deeper, using 3-inch special alloy National Tube drill pipe, and has an excellent opportunity of contributing additional records to deep drilling history by reaching a depth never before penetrated by machinery. An article giving the drilling history of this well appeared in the September issue of THE PETROLEUM ENGINEER. The bottom of the hole is now at 10,079 feet—49 feet deeper than any test well yet drilled in the United States and 506 feet short of the world's record.

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Fifteen-Year-Old Machine Shop Proves Economical Investment

A LARGE machine shop has been a most economical investment during its 15 years of work for the L. H. Wentz interests of Ponca City. The plant is located in the old Dilworth field of northern Oklahoma, where Wentz drilled some of his first oil tests. It remains, today, the central point for all company field materials. Every type of machine shop work needed in the oil fields is done in this shop, including ignition service, all engine repairs, pipe threading and cutting, cutting of nipples from seamless tubing and pipe, gate valve repairs, pump repairs and all general work.

Equipment brought to the shop for repairs is cleaned, then taken apart and carefully inspected. When worn parts are found they are either reconditioned by machining or replaced with new or rebuilt parts. When a piece of machinery is found badly worn and of little possible value for future field service all the good parts are salvaged and frequently used on another piece of equipment of the same type.

The shop building is a high-roofed structure, permitting plenty of fresh air and light for the workmen. The machinery is placed around the side of the building as much as possible so as to get better light and leave the center of the floor available for storage, cleaning and inspection work.

The pipe cutting machine, of heavy type, is at one end of the building and an opening in the side of the building walls permits feeding long lengths of pipe into the machine. A 15-horsepower gas engine furnishes the motive power for the shop, operating the various machines by means of an overhead belt drive.

Ample storage grounds provide room for keeping an adequate supply of repaired equipment on hand, ready for quick shipment to any point. The storage yard includes several acres of ground devoted to stacks of pipe and casing and docks for machinery. Heavy raised timber supports keep the pipe off the ground, permitting it to drain easily and preventing it from gathering foreign matter that might cause or hasten corrosion.

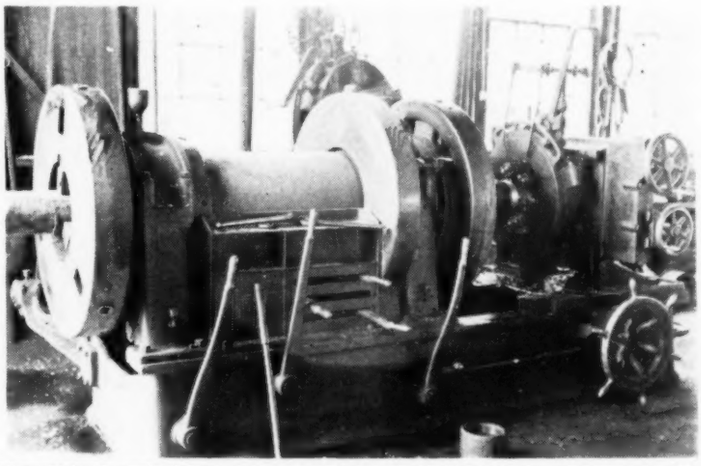
Each of the many storage docks is used for one type of equipment, such as engines, compressors, slush pumps, gate valves, etc. All the docks are so situated that a truck can easily back up to them. One dock is used for storing small equipment, including fishing tools, bits and small drilling and production tools. This dock is equipped with an upright crane mast to aid in loading or unloading. The equipment is carefully racked on inverted "V"-shaped stands, made of old small-diameter pipe and wooden planks, bolted to the wooden dock floor. Three racks of this type are on the dock, with ample aisle room between.

Yard and machine shop handling of heavy equipment is simplified by an abundance of overhead crane trackage, running in two directions from the shop.

The Wentz properties in the Dilworth pool form a complete unit, including, besides the machine shop, a large number of producing wells and their flowing and pumping equipment, a gasoline plant, ice plant, water plant, garage, electric generating station, field offices, warehouses and company-owned houses for the employees.

The wells are among the best producers in the state, yielding high gravity oil with a steady flow that has placed their cumulative output up among the state's better wells. Many of these wells were drilled back in 1915, but are still pumping sufficient oil to make their operation profitable. Several producing sands have increased the value of the large amount of acreage held by the Wentz interests and only recently a new well was completed, which proved additional holdings in the pool to be productive.

A feature of the power for running the various units making up this complete property is the widespread use of gas engines as prime movers. Sufficient gas for fuel is obtained from the company's gasoline plant. All wells, whether on the beam or central power, are pumped with gas engines as power. In addition to the machine shop, the electric plant generators are run by a 60-horsepower gas engine. This plant furnishes all power for electric lights and for operating the ice plant. Every morning ice and water are delivered to the homes of the employes. Water is supplied to the district, including the supply for other companies operating in the district and for many farm homes, by means of a six-inch main line from a river 20-odd miles away. A modern water station pumps the water from its source to a treating plant in the field.



Pipe-cutting machine in the Wentz shop.

BETTIS PROTECTORS ON A STRING OF DRILL PIPE FOR 3 YEARS —

A well known superintendent (name on request) in the Long Beach (Calif.) field, reports the following service:

"We have used Bettis Protectors on a string of 4" drill pipe and found that they were a great protection for both our casing and drill pipe.

"I purchased the Protectors in February, 1928, when we were side-tracking a 6¼" liner and having a very hard time starting. Every time we would pull out, the tool joints and collars would be worn bright from the drill pipe rubbing on the casing. I had Bettis Protectors put on the string and the driller immediately noticed how easily the drill pipe rotated and that the wear on the tool joints and collars ceased. We remained between the depths of 2950' and 3175' for two months, getting started off and then side-tracking a mill that was lost in the hole.

"If we had not installed the Protectors the 8¼" casing would have worn out. We finished using the 4" drill pipe and laid it down in May, 1928, with the Protectors still on the pipe. The string of drill pipe was not used again until April, 1930. The Protectors were found in very good condition and still are in use. Furthermore, the Protectors have not shifted on the pipe but are right where we put them in the first place.

"The next time that we are in need of Protectors I will certainly consider the Bettis the best buy, because from my observation and experience the rubber in the Bettis Protector seems better than that used in other types of Protectors; there is a time saving in the installation, and they stay where installed."

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BETTIS PROTECTORS and DRILL STABILIZERS

Recent Developments in Automatic Rectifier Control

By LOUIS H. BRENDEL and E. H. HAMMOND[1]

THE design of a modern rectifier, or stabilizer plant, has passed through the experimental stage and is now an almost exact science. Give the design engineer the quantity and quality of raw feed, and a set of vapor pressure curves, and he will tell you the range of finished products it will be possible to obtain. A little more time, and a few more curves, and he will tell you the size and number of plates in the rectifier, the reflux ratio and the surface in the exchangers, reboiler and condensers, and will wind up by guaranteeing the percentage of each hydrocarbon in the finished product. The engineer, however, will be somewhat like the broker, in that he will qualify his guarantee with an "if, as and when" clause. In other words, he will tell you that the desired product cannot be obtained unless there is a constant feed rate of uniform composition, constant reboiler temperature, constant operating pressure and constant reflux rate (or top temperature). The design of the entire plant is based on the assumption that these four factors will remain constant, and a variation in any or all of them will seriously upset plant operation.

The name of "stabilizer" as applied to the column was derived from the nature of the finished product, and not from any characteristic pertaining to ease of control. As a matter of fact, the operation of a stabilizer is anything but stable, and the obtaining of proper automatic control has in the past presented a real problem. Of the four factors which must be held constant, the feed and reflux rates are the easiest to control. Rate of flow controllers operating diaphragm motor valves in the steam lines to the feed and reflux pumps will maintain a fairly constant mean rate of flow, but due to the lag in the control system there will be a variation in the instantaneous rate. The feed composition is usually beyond the control of the operator, as it depends on absorption plant operating conditions. Ample raw gasoline storage is the best insurance for constant composition.

Constant column pressure is essential, but, fortunately, it is relatively easy to maintain. A sensitive pilot-operated back pressure regulator on the wild gas line from the reflux accumulator will maintain the pressure constant within a 3- or 4-pound total variation. However, excellent control is obtained with a new type pressure recorder controller throttling a diaphragm motor valve in the wild gas line. This instrument is so sensitive and accurate that it will maintain the pressure constant throughout the 24-hour period without visible variations. See instrument chart (Fig. 1).

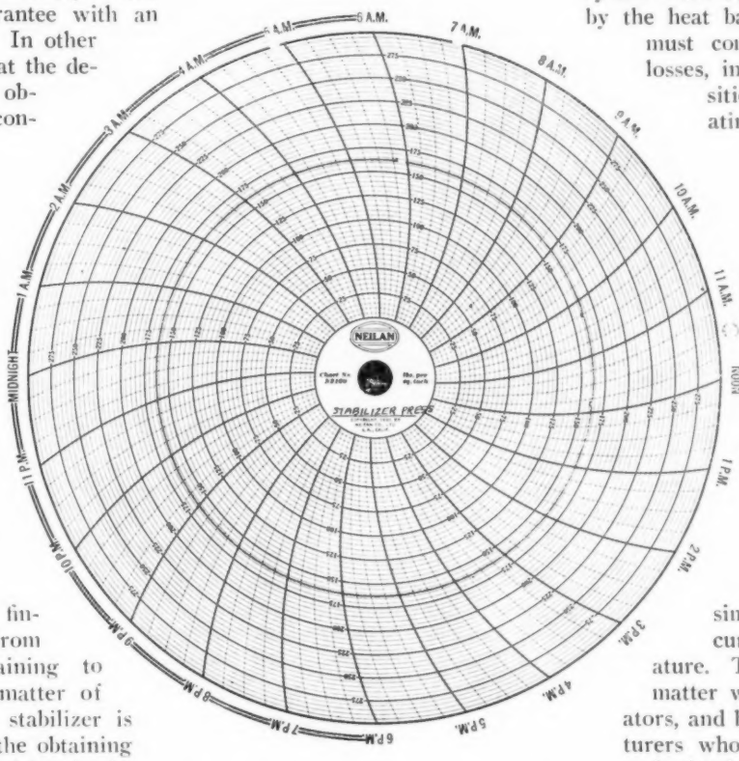

Fig. 1—Chart showing how accurately the pressure in the stabilizer can be held by means of a pressure control instrument operating a control valve.

We now come to the real control problem—constant reboiler temperature. The reboiler is the thermal balance wheel of the entire rectifier unit. Its heat input to the system must equal the deficit determined by the heat balance, and in addition it must compensate for all thermal losses, inequalities of feed composition, and variation in operating conditions. It must also act as a watch dog for the rectifier, driving off as a vapor any undesirable hydrocarbons remaining in the stabilized gasoline leaving the column. Since the liquid and vapor phases in the reboiler are in equilibrium, the reboiler temperature must of necessity be such that the vapor pressure of the product will equal the column operating pressure.

On first thought it would appear to be a simple matter to control accurately the reboiler temperature. That it is not such a simple matter will be attested to by operators, and by the instrument manufacturers who have spent many dollars and sleepless nights endeavoring to accomplish this result.

In the following discussion it will be assumed that steam is used for heating the reboiler, as this is by far the most common heating medium.

There are two methods by which the reboiler temperature may be controlled. One is to hold as nearly as possible a constant pressure in the heating coils by means of a pressure-reducing regulator in the steam line, or by the use of a pressure controller actuated by the steam pressure in the coil, and throttling a diaphragm motor valve in the steam line. The other and more common method is the use of a temperature recorder controller with the thermal bulb in the liquid or vapor space of the reboiler, and throttling a diaphragm motor valve in the steam line.

The first method is essentially one of constant heat input

[1]Neilan Co., Ltd.

to the reboiler for any given steam pressure, and its accuracy, therefore, is subject to any and all factors which would tend to change the heat transfer rate from the condensing steam through the tube walls to the liquid. Changes in steam quality, and velocity through the tubes, and sticking or intermittent dumping of the steam trap will affect the heat transfer, while changes in feed rate or composition, liquid level in the reboiler, and atmospheric temperature all tend to change the reboiler temperature. The result is an oscillating chart record which may have as much as a 10-degree total variation and which drifts with the atmospheric conditions.

The second method is more sensitive than the first, but has the inherent disadvantage that the ordinary type of temperature recorder controller is called upon to correct a change that has already taken place, rather than having anticipated and prevented the change. In other words, the reboiler temperature must have already changed before the usual instrument can act to effect a temperature correction. This naturally results in a sharp overrunning or hunting which is manifested on the chart by a sharp zig-zag record of from 4 degrees to 10 degrees total variation. This control is also affected by changes in feed rate and composition, and by those factors which influence the heat transfer, and the chart record will usually show a drift of several degrees throughout the 24-hour period.

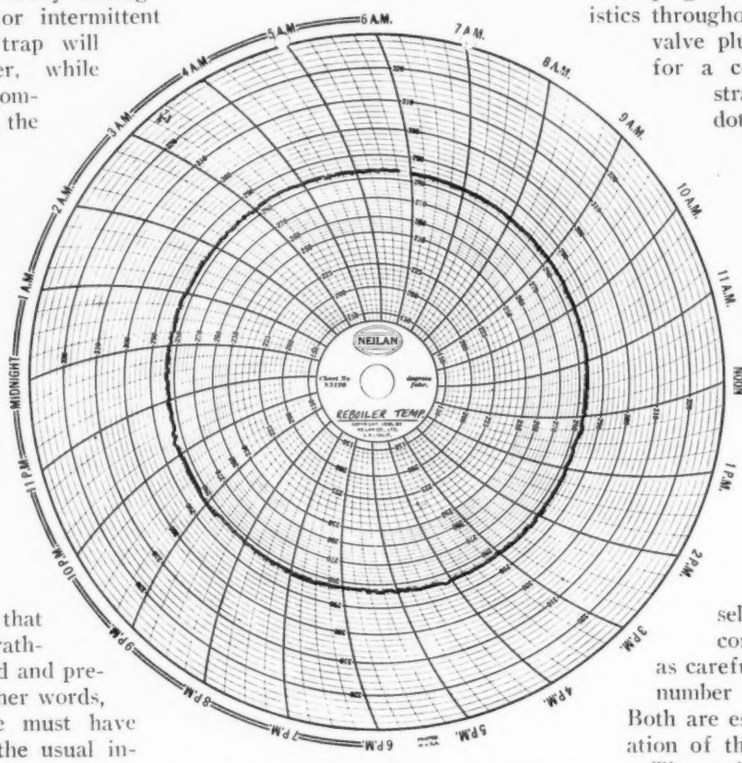

Fig. 1-A—Type of temperature chart made on tough rectifier control job by the new thermo-pressure compensated temperature recording controller.

A big improvement in control was made possible by the development of an improved type of diaphragm motor valve utilizing the parabolic type of gradual opening balanced valve plug with full throttling characteristics throughout the entire travel of the valve plug. The ideal flow curve for a control valve would be a straight line, as shown by the dotted curve in Fig. 2. The left-hand ordinates of this curve are diaphragm pressures, the abscissae are units of flow, and the right-hand ordinates are percentages of valve opening.

While the new and improved type of diaphragm motor valve has done much to improve control, it cannot correct for errors and improper design which are inherent in the instrument itself. For this reason the selection of a temperature recorder controller should be as carefully made as is the size and number of plates in the column. Both are essential to the proper operation of the plant.

The action of the instrument and the diaphragm control valve should be synchronized and the instrument should be capable of anticipating and preventing changes in temperature. Such changes may be caused by variations in the feed rate and compensation, steam pressure and quality, flooding of coils with condensate, changes in liquid level and fluctuating atmospheric

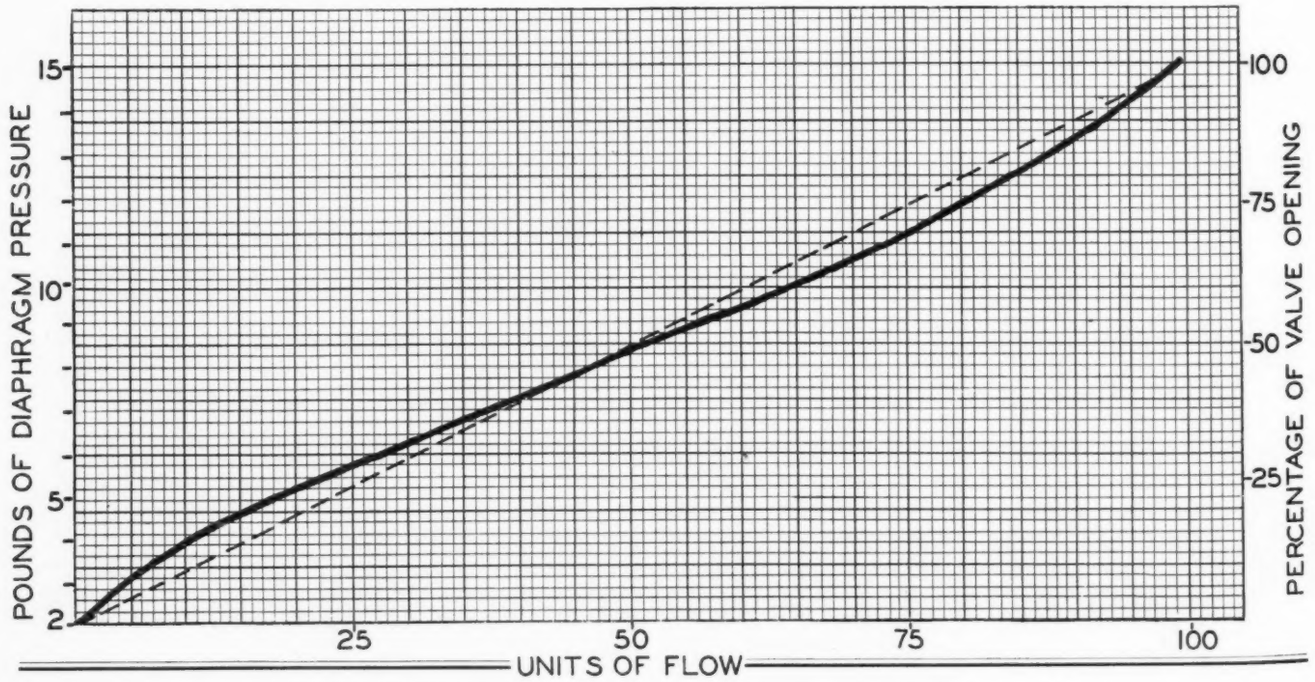

Fig. 2—Heavy line shows how closely the parabolic type of control valve approaches the perfect straight line.

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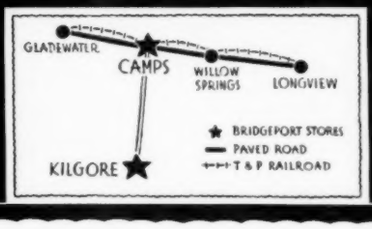

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conditions. Fig. 3 is a simple flow sheet of an actual low-pressure stabilizer properly equipped with modern control instruments, control valves and regulators. The column and accessories are designed for handling feed stock of widely varying composition and quantity, and the operation is extremely flexible.

The unit is fully and automatically controlled with:

(a) Reboiler temperature recorder-controller with the bulb in the liquid space of the reboiler and controlling a diaphragm control valve in the steam line to the reboiler. A recently-developed instrument for this service embodies a distinctly new idea which interconnects the reboiler temperature and the pressure of the heating medium.

(b) Pressure recorder-controller holding a constant pressure on the column by actuating a diaphragm control valve in the wild vapors from the accumulator.

(c) Liquid level controllers—both the regular pilot-operated type and the newly-developed instrument type for high gravities are used, depending on the gravity of the liquid in the reboiler and the accumulator.

(d) Orifice meters on the overhead and finished product.

(e) Rate of flow recorder-controller on the feed and reflux, diaphragm control valves in the steam lines to the pumps.

The reproduced charts (Figs. 1 and 1-A) clearly indicate the type of control possible with properly selected instruments and control valves and represent a typical 24-hour run.

Perhaps the most interesting advancement in the field of automatic control for rectifiers has been made in the temperature field. Like most worthy developments, it consists of a principle so basically simple that one wonders why it had never been perfected previously. Briefly, it is a means of mechanically interconnecting the temperature which is being controlled with the pressure of the heating medium in the same temperature control instrument. The close interrelation of temperature and pressure as applied to the rectification of gasoline has long been appreciated by many design and plant engineers.

Experiments and research disclosed that anywhere from 30 seconds to 3 minutes prior to the time that a temperature change was indicated by the temperature recorder, the pressure of the heating medium going to the reboiler heating coils varied noticeably. Obviously, this might have been caused by (1) variable upstream pressure of the heating medium, (2) periodic emptying of steam traps, (3) varying the rate or temperature of the make-up in the vessel. This led to the belief that if each variation in temperature is preceded by a change in the pressure of the heating medium, then if the heating medium pressure were held exactly constant the temperature control task would be simplified. It was found, however, that the reduced pressure of the heating medium had to be reset for each different set of temperatures or conditions desired.

To overcome this in the new temperature controller, a helical pressure coil is close coupled with a helical temperature coil. The pressure coil is actuated by the reduced pressure on the downstream side of the heating medium control valve. The helical temperature coil has its bulb in the regular way inserted into the reboiler. Naturally, such an instrument is exceptionally sensitive because now the slightest change in pressure of the heating medium, which might not cause a temperature change for 30 seconds, is effective through the instrument to the control valve so as to remedy the pressure variation. In this way the pressure is corrected before it has had time enough to alter the temperature of the fluid in the vessel. In many cases this new type of thermo-pressure compensated instrument is providing closer temperature control than has ever before been experienced on rectifier service.

The problem of suitable liquid level controllers, especially for service with extremely high gravities where the lightness of the liquid provides very little power to operate the valve, is believed to have been solved by an instrument type controller. With the increased interest in propane, butane and other commercial lighter fractions, instrument liquid level controllers will play a growing part.

Developments such as have been herein briefly sketched are important to the petroleum industry because they make possible the perfection of newer and more efficient processes. They are of further value at times such as the present because they point the way to greater production and economies in older plants.

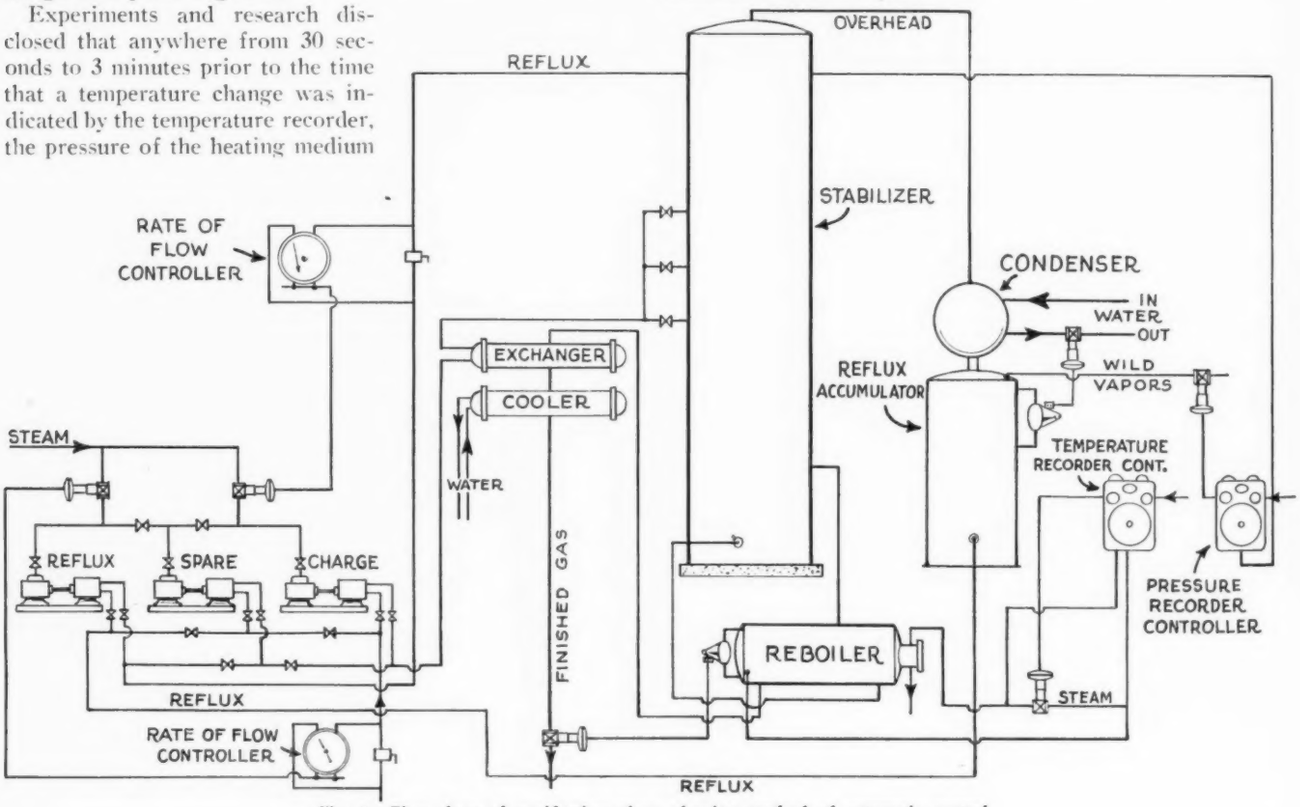

Fig. 3—Flow sheet of rectification plant, showing method of automatic control.

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(Above) Photo No. 2--Night Drilling Scene Enlargement 13" x 16½"

(Below) Photo No. 3--Ice Covered Derrick Enlargement 13" x 16½"

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The Selection and Maintenance of

Control Equipment for Squirrel Cage Industrial Motors

By T. D. WILLIAMSON*

Ten low voltage across-the-line type starting switches and one low voltage automatic compensator controlling motors in the centrifuge plant of an eastern refinery.

DURING the past few years manufacturers have made wonderful improvement in the design of electric motors, adapting them to the exacting conditions for which they were required. In order that these installations be consistent, it has been necessary for the manufacturers of control equipment to redesign and improve their devices, to meet the same exacting conditions. It is now possible to select the complete equipment to meet the most exacting requirements, knowing that the entire installation is equally safe and dependable.

In selecting motor control equipment a number of conditions and requirements should be taken into consideration. These could be summarized as follows:

(1) Location of proposed installation:
  (a) Inside building.
  (b) Outside building.
  (c) Hazardous.
  (d) Non-hazardous.

(2) Size and type of motor to be controlled.

(3) Capacity and rating of electric generator system to which motors are to be connected.

(4) Automatic operation.

(5) Manual operation.

Control equipment, as well as the motors with which they are to operate, are now especially designed for the location in which they are to be installed. If the installation is indoors, in an ordinary industrial plant, where no gas, dust or fume hazards are present, the equipment is designed for proper protection, both to equipment and operators.

Recently a number of oil companies have found distinct advantages in installing certain motor equipment out of doors. These consist principally of centrifugal pump applications, where the pump unit is installed near the equipment with which it is to be used. Motor manufacturers have designed weatherproof equipment, and now motor control equipment is similarly designed and available. This usually consists of magnetically-operated contactors, either air break or oil immersed, installed in cast iron cases, with gaskets, which renders them thoroughly weatherproof. These are operated by means of push button stations, which are also designed for outdoor installation.

In some industrial plants, due to lack of floor space, automatic starters, compensator or "across the line" type, are installed either on the roof or on the ground outside the building. This control equipment must be of the weatherproof type, and is controlled by means of push button stations, located near the machine which the motor operates.

Within the past several years the National Board of Fire Underwriters has passed some very strict rules covering electric equipment for use in rooms containing hazardous gases or fumes. These requirements have caused motor manufacturers to build "Explosion Proof" motors, hence control manufacturers have been required to build equipment to meet similar conditions. The control equipment usually consists of magnetically-operated contactors, enclosed in cast iron cases which are designed to withstand

100-horsepower, 2300-volt automatic compensators that control motor driven pumps handling distillate. Above each motor is an oil-immersed master switch for local starting and stopping of the motors. Similar master switches are located at each pump for remote control.

*The Petroleum Electric Co.

an explosion force within the case. In order to be consistent, it is also necessary that the push button control station be "explosion proof," and approved by the National Board of Fire Underwriters. Such a control station consists of a cast aluminum case, with the switch contacts immersed in oil.

In selecting control equipment with regard to location of installation, therefore, the same requirements should be met as those for which the motors controlled are designed. Consideration should also be given to the providing of ample protection to the control equipment, when installed outdoors, to be sure that the enclosing case is thoroughly weatherproof, with proper gaskets around the doors to prevent entrance of moisture.

Two general classes of control equipment are now provided for the squirrel-cage type motor, one of which is the "compensator," which applies reduced voltage at starting, and after the motor has attained partial speed, full voltage. The other class of starter, known as "across the line" type, applies full voltage of the service line at starting. The tendency of engineers is toward the "across the line" type starter, regardless of size or voltage of motor. This recommendation is justified by reduced first cost, simpler control and fewer parts to maintain. However, the source of electric power must be taken into consideration. If the motors are served by a large power system, and are located some distance from cities or towns where the dimming of lights would not be objectionable, then it would be good practice to install "across the line" type control equipment, regardless of the size of the motor to be started. If, however, the generating station is relatively small, especially in proportion to the motor load, then the "compensator" type control units should be used, as they serve to reduce the heavy starting load on the generating equipment, and also prevent the dimming of lights which are connected to the same power system.

Low voltage automatic compensators at refinery crude oil booster pump house.

Two general types of "compensator" starters are in common use; the manual and the solenoid or automatic types. The manual type is entirely hand-operated, and the time at which the change is made from partial to full voltage, to be applied to the motor, depends entirely upon the judgment of the operator. When first cost is of prime consideration the manual type starter is selected. From the standpoint of advanced engineering the automatic compensator is always selected, even though the first cost is somewhat higher. The principal advantages of this type equipment are:

(a) The change from partial to full line voltage is entirely removed from the control of the attendant, and always takes place at exactly the right time. This is controlled by relays within the equipment.

(b) The control equipment may be located in any out-of-the-way place, and the push button control station installed near the motor which is being controlled.

(c) If the motor operated equipment, such as pumps or compressors, is to be automatically controlled, by means of floats, pressure gauges, etc., the automatic starter is required.

There are a number of construction details in starting equipment, which should be taken into consideration in selecting the most suitable device for the particular purpose.

One of the most essential parts of the control equipment is the overload protection afforded the motor. Originally the design of this device was based upon the current, drawn by the motor, operating a solenoid. When the current became excessive, the solenoid was lifted which opened an electric circuit and caused the main contacts of the control to open. Since the limiting factor in the capacity of motors is the "heating" of the windings within the motors and not its mechanical strength, modern protection devices are based upon a heating coil, the excessive temperature of which serves to disconnect the motor from the service lines. These devices are designed to simulate the exact motor temperatures, thus limiting the heating of the motor, in accordance with the temperature of the room in which it is operating. In selecting control equipment, serious consideration must be given to the overload protection, to be sure that this device is so designed that:

(a) Adequate protection is provided in case of "single phase" operation of the motor. That is, when one of the three service lines to the motor becomes disconnected, due to melting of a fuse, or defective lines. "Single phase" operation is the cause of burning out of numerous motors.

(b) Excess momentary load on the motor will not cause the "heating coil" of the overload device to burn out. In some types of control, if the overload device is adjusted finely enough to protect the motor against "single phase" operation, the heating coils are so fine that they easily burn out.

(c) Adjustment of the required per cent of full load on the motor may easily be accomplished. In some controls this change is made by turning a small knob, within the control, having a dial and pointer indicating the per cent of rating; for example, 100 per cent — 125 per cent—150 per cent.

(d) It is thoroughly reliable —cannot stick or "freeze," and will always open the control circuit to the motor in case of excess load.

(e) May be easily replaced in case of damage, and may be changed to correspond to a change in the horsepower rating of the motor being controlled, within the range of the control equipment.

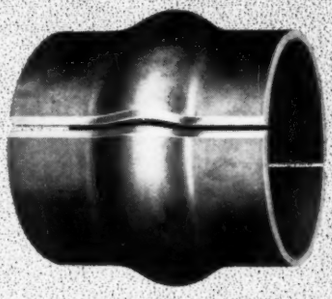
Another important detail of control equipment is the design of the main contacts. These should be sufficiently large, not only to carry the motor current, with an adequate factor of safety, but mechanically strong to withstand the shocks sustained when making contact. They should be easily replaceable, for this portion of the control equipment is subject to continuous wear, due to burning when the circuit is opened. If possible, burning tips should be provided, wherein the electric arc is finally broken, thus preventing burning of the main contacts, which results in poor conducting capacity.

In the best designed oil immersed controls, the main contacts are placed as high as possible in the oil, allowing sufficient immersion to quench the electric arc. This arrangement is made because the sediment or sludge in the oil, which settles to the bottom of the tank, would cause a short circuit should it reach and cover the main contacts. Thus, with this design, changing of the oil is required

MIDWEST
WELDING 90° ELL

MIDWEST
WELDING 45° ELL

MIDWEST
WELDING HEAD



MIDWEST
WELDING SLEEVE

MIDWEST
WELDING SADDLE

THE GREATER
MIDWEST PIPING SERVICE

THE application of Midwest Welding Fittings to many types of piping systems means reduced costs and improved designs that were not previously possible.

Midwest Welding Ells, 90° and 45°. Dimensional accuracy and uniformity are exceptional. A special *compression* sizing operation finishes Ells to exact radius and sectional diameter and in perfect round. Tangents reduce the time and cost of installation.

Each Ell is made from *one piece* of plate by a special process developed and patented by Midwest; there is one welded longitudinal seam along the inner circumference. Final working of the metal is at welding heat and in *compression*, thus normalizing and refining the metal in the weld and the plate—it is not extruded or stretched.

Standard weight Ells stocked from 2″ to 16″ and extra heavy from 2″ to 12″.

Midwest Welding Head. The ellipsoidal form reduces unit stress in the metal to a minimum. The long tangent puts the circumferential weld to the pipe entirely in tension—it is not subjected to shear and bending. Application is much easier and a neat appearing job is assured.

Standard weight and extra heavy Heads carried in stock from 3″ to 24″.

Midwest Welding Sleeve. Used to reinforce a butt line weld between two pieces of pipe, it relieves the butt weld of any bending stress and much of the tensile stress to which it would otherwise be subjected. Transverse recess in sleeve permits its application over the conventional line weld.

Sleeves are carried in stock from 4″ to 24″.

Midwest Welding Saddle. It not only reinforces the junction of neck and body of a welded header, but also compensates for the weakening of header body that results from loss of the metal cut out for the neck opening. Tests proved this saddle materially increases the strength of a welded header over customary gusset plate construction.

Made in sizes from 4″ x 2″ to 24″ x 24″. Thickness varied to suit service requirements.

• • •

Midwest Welding Fittings are made from the same material as mild steel pipe—consequently, they have the same coefficient of expansion and the same welding characteristics. On special order, they will be made from genuine wrought iron or any of the standard alloys.

See Bulletin WF-2 for complete information.

MIDWEST PIPING & SUPPLY CO., Inc.

Main Office: 1450 South Second St.
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Offices: Chicago, 208 So. La Salle Street . . . Houston, 600 Bringhurst Street . . . Los Angeles, 520 Anderson Street . . . New York (Ballwood Div.), 30 Church Street . . . Tulsa, 733 Mayo Bldg.

MIDWEST MIDWEST MIDWEST MIDWEST MIDWEST MIDWEST MIDWEST MIDWEST MIDWEST MIDWEST MIDWEST MIDWEST

much less frequently than when the main contacts are located near the bottom of the oil container.

Two general schemes of control are in use in connection with squirrel cage motors, utilizing automatic starting devices. One of these schemes is based upon the restarting of the motor operated equipment automatically, after failure of power for a short period. The electrical connections between the control station and the starting device consist of but two wires. This scheme of control is applicable to centrifugal pumps, air compressors and other machinery that must be kept running continuously, the unexpected starting of which would not endanger the lives of the operators. These control stations are designated as "no voltage release" by the manufacturers of control equipment.

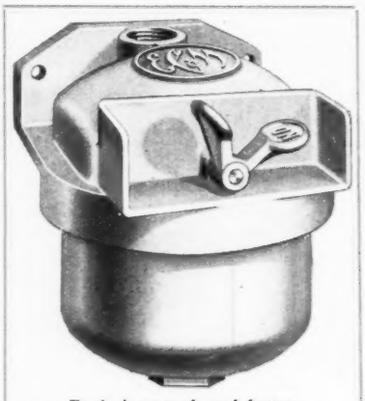
In the second scheme of control, after failure of power for a short time, the motor-driven machinery will not restart until the attendant has operated the "start" button of the control station. For this control system three wires are required between the control station and the starting device. This system is particularly adaptable to the control of machine tools and other equipment, the unexpected starting of which might endanger the lives of workmen. Control stations designed for this operation are designated as "no voltage protection" by manufacturers.

Control stations, for use with automatic starters (either "compensators" or "across the line" type), are designed in accordance with the location of the installation and the safety features which must be provided. In general they may be divided into the following classes:

Open Type, Weatherproof, Explosion-proof.

The open type station may be used indoors, under normal operating conditions, and where no hazardous gases, fumes or dust exist. The weatherproof type control station is designed for out-of-door use. It must be made moisture-proof, with gaskets under the covers or tight thread joints.

In locations where "explosion-proof" motors as starters are required, the "explosion-proof" control station must be used to meet the fire underwriters' requirements. These stations must be approved by the National Board of Fire Underwriters for use under these conditions. The case must be exceedingly heavy and the contacts should be oil-immersed.



Explosion-proof push-button (oil-immersed or air-break).

When the control station is located at a distant point from the motor-starting equipment it is sometimes desirable to be able to "reset" the overload protective device, after it has opened the switch, without having to visit the motor starter. This is accomplished by means of a "reset" contact in the control station, which, when the electric circuit is completed, energizes a coil in the motor starter overload device, which resets this device, ready for the motor to again start.

Good design requires that all working parts be easily accessible for inspection and repairs, and those parts that are subject to wear, or may become damaged in operation, are readily removable. Accessibility encourages systematic inspection by the attendant.

The successful operation of control equipment depends upon:

(a) Proper selection, to meet the operating conditions.

(b) Correct installation.

(c) Adequate inspection and maintenance.

Assuming that the first two requirements have been complied with, the following is a brief outline of the attention which should be given control equipment to insure successful operation.

Systematic inspection is essential, and to insure inspection at regular intervals a record—card system preferred—should be kept of each piece of equipment. This record should contain a complete description of the device, as given in the manufacturers name plate, date of inspection, condition of equipment, and list of any parts which must be replaced or repaired. With this record system, a comparison of the cost of maintenance of different makes of equipment may be made, and that make which requires fewest repairs, and which is the most satisfactory, may be intelligently selected.

Modern control equipment is designed with the fewest possible working parts and these of sizes and strength to require the least possible attention. However, certain parts of all control equipment must be inspected at regular intervals.

The parts of the control devices subject to the greatest wear are the main contacts. The rough or burned parts should be smoothed and cleaned with a fine file and sand paper. Do not use emery paper, as the fine particles of emery become imbedded in the relatively soft copper of the contacts and cause excessive wear. When the contacts become sufficiently worn that adequate contact is not made, or the current capacity of the parts is considerably reduced, they should be replaced.

The oil, of oil-immersed starters, should be inspected at regular periods, to determine that the insulating strength has not been reduced by the presence of moisture or sludge sufficiently to make it unsafe for use.

When the oil under test shows presence of water or sludge, it should be run through a filter machine. For convenience and safety the drain connection of the controller tank should be connected through a pipe line to an outside storage tank which is buried in the ground. Thus when inspection or repairs are made, or the controller tank is to be cleaned, the oil may be drained into this storage tank by opening a valve. Also, in case of fire, this oil should be drained into the storage tank to prevent possibility of its becoming ignited.

Secondary contacts, in the overload devices, should be inspected to determine that they are operative, not having become welded together, or stiff, which would render them inoperative in case of an emergency.

Cleanliness is one of the essentials of successful operation. The equipment inside the case should be thoroughly cleaned of dust and grease. For the removal of the latter a non-inflammable liquid, such as carbon tetrachloride is preferable and safer than gasoline. The exterior of the control equipment case should be thoroughly cleaned at regular intervals.

With the systematic inspection and maintenance suggested above, modern control equipment could be operated for an indefinite period. Burn-outs and failures would be prevented for the worn or weakened parts would be discovered and replaced before disastrous conditions resulted.

In conclusion, modern control equipment gives entirely satisfactory results, when properly selected to meet the installation and operating conditions, correctly installed and adequately inspected and maintained.

The NEW LONE STAR
NO. 1008

WEIGHS LESS ★ STEAMS BETTER

Here's Why—

This new Boiler is 2 to 4 feet shorter than others of equal rating, but its fire-box heating surface is as much as 75% greater. Tubes are smaller and shorter, but more numerous. Design puts a maximum heating surface closest to the fire. Thermic Syphon is an efficient attachment.

Obtain Folder No. 435

COMPARE THESE SPECIFICATIONS

A. S. M. E. Code Construction

Nominal Horsepower	100
Working Pressure	250 #
Length Overall	19′ 8″
Heighth Overall	10′ 9½″
Width Overall	61″
Length Fire Box	84″
Heighth Fire Box	65″
Width Fire Box	51″
Volume Combustion Chamber	161 Cu. Ft.
Number and Diameter of Tubes	156 – 2¼″
Length Tubes	10′ 6″
Weight of Boiler	23,000 #

OIL WELL SUPPLY CO.

Branch Stores in all Oil Fields

SUBSIDIARY OF UNITED STATES STEEL CORPORATION

1744

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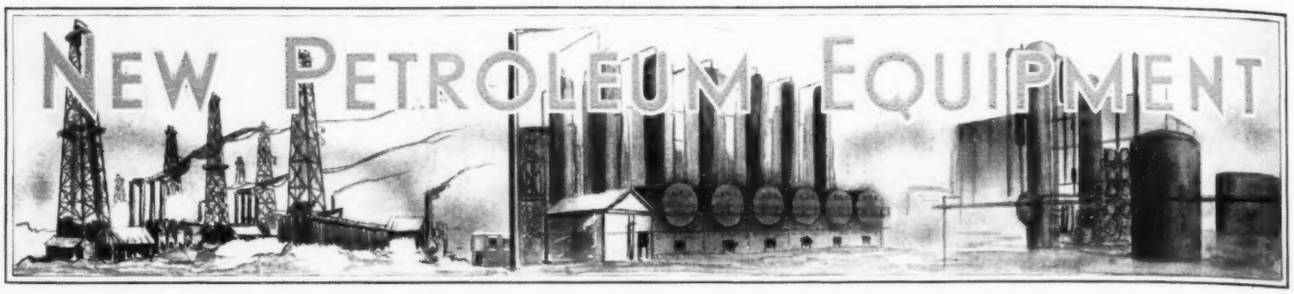
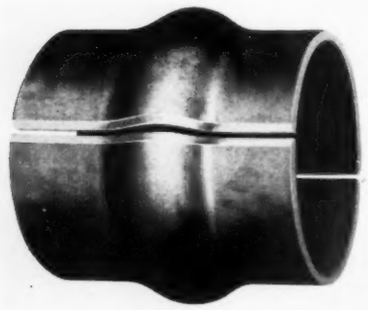


Chapman Lubricated Plug Cocks

THE Chapman Valve Manufacturing Company, Indian Orchard, Mass., is presenting a new design in lubricated plug cocks, which is said to have the advantage of securing the essential vertical movement of the plug through entirely mechanical means. The first action is the lifting of the plug by a threaded stem, just as in a gate valve. The amount of lift is definitely predetermined so that the clearance around the plug is a matter of very minute dimensions.

When sufficiently lifted to gain clearance, the plug is rotated and a grease seal can be established between the plug and body. All plugs are ground and lapped into the bodies to insure perfect fit.

Midwest Welding Sleeve



MIDWEST Piping and Supply Co., Inc., St. Louis, Mo., has placed on the market the Midwest Welding Sleeve, which is used to reinforce a butt line weld between two pieces of pipe. According to the makers, this sleeve relieves the butt weld of any bending stress and much of the tensile stress to which it would otherwise be subjected; the purpose of the butt weld then becomes principally that of keeping the joint tight.

The transverse recess in the Midwest Welding Sleeve is important—it permits the application of the sleeve over the conventional line weld. Each half of the sleeve is slightly less than a semi-circle to assure a snug fit against the pipe even when its outside diameter varies the maximum permissible amount under standard diameter.

Acitite, an Acid-Proofing Product

THE Sullivan Company, Memphis, Tenn., has perfected a product known as "Acitite" for acid-proofing cement mortar joints, cement coatings, etc. It is 100 per cent immune to sulphuric, muriatic, hydrochloric and other strong acid solutions and is particularly adapted for mortar joints between brick or tile for floor work where strong acid solutions are to be used.

It has the advantage of being quick-setting, hardening within a few minutes of application. Its use is simple, requiring no other ingredients, and is a completely homogeneous compound of low specific gravity (about 2), shipped in granulated or solid form, and melts over moderate fire at 250 degrees F.

Hercules Small Series of Fours

THE Hercules Motors Corporation, Canton, Ohio, is now manufacturing a line of small, modern four-cylinder engines and power units designated as the Hercules IX series. Models are available in the following bore, stroke and displacement:

Model	*Size*	*Displacement*
IXA	3 in. x 4 in.	113.1 cu. in.
IXB	3¼ in. x 4 in.	132.7 cu. in.

The IX series engines and power units embody the usual Hercules fundamental characteristics and simplicity of design and construction. They are designed and built for heavy-duty purposes and according to the manufacturers are arranged to accommodate all modern accessories.

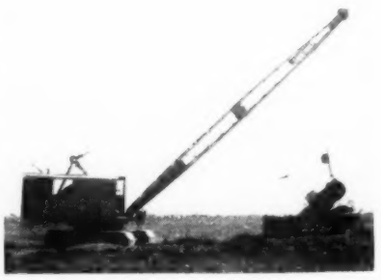
Square D Calculator

DESIGNED to compute complete wiring and motor data, the Square D Calculator is now being offered the trade by the affiliated Diamond E-Square D organization. It is said to be a handy, compact unit containing two separate and distinct calculators, one computing wiring, the other computing motor data. Its figures are distinct and legible and are protected by a waterproof celluloid covering.

The calculator fits conveniently into the pocket. Because of its substantial construction, rough handling cannot in any way upset its precise calculations. Based on the latest issue of the National Electrical Code, it is reliable. Its operation is simple and its computations accurate and dependable, the manufacturers state. Additional information on this calculator may be secured from Diamond Electrical Manufacturing Company, 1320 East 16th St., Los Angeles, Calif.

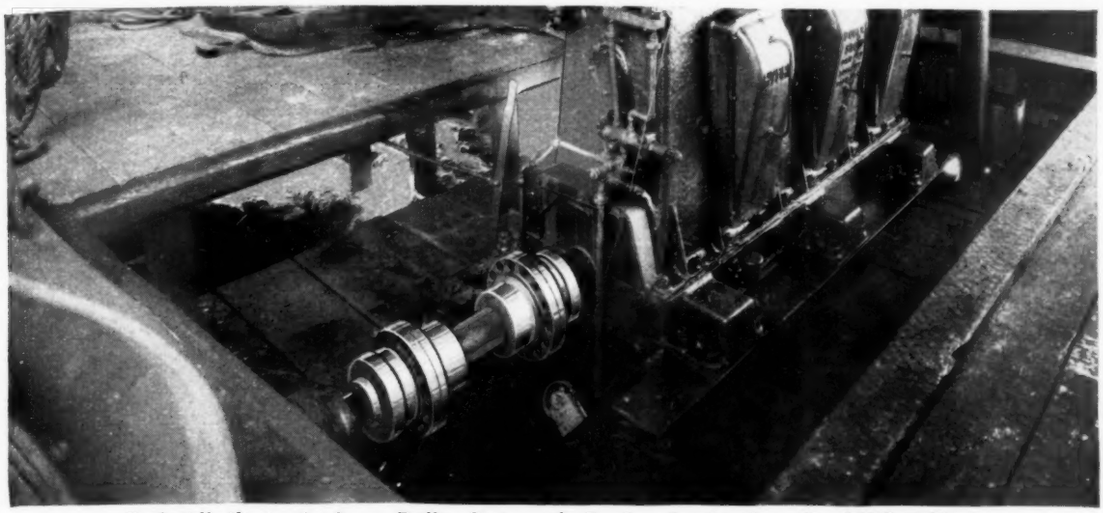
Link-Belt Shovel-Crane-Dragline

LINK-BELT Company, Chicago, Ill., has announced the addition of a new shovel-crane-dragline, known as K-48, to their line which ranges from ¾ to 2½ cu. yd. capacity.

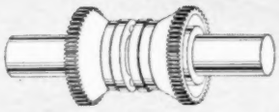


It is an all-purpose unit, according to the makers, serving as a shovel, a crane, a trench hoe or a dragline. It can be furnished with any or all of the attachments which are usually only available on smaller machines. The K-48 is arranged for gasoline engine, Diesel engine, or electric motor drive. The gasoline engine has a 130 horsepower rating and the Diesel or electric motor is of corresponding capacity.

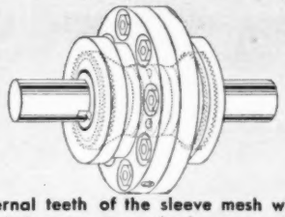
STOP WEAR BEFORE IT STARTS



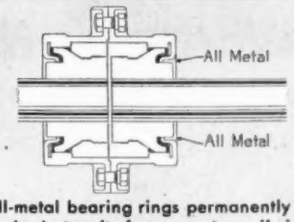
Fast's Self Aligning Coupling on Drilling Engine at the Petroleum Securities Corp., Signal Hill, California



The two hubs carry generated spur gears

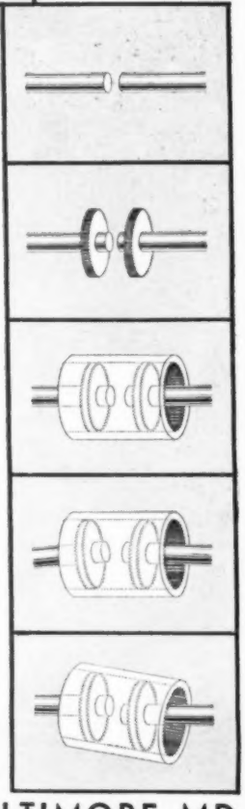


Internal teeth of the sleeve mesh with the hub gears, the entire inner assembly always in a clean oil bath.



All-metal bearing rings permanently exclude dust, grit, fumes, water, eliminating the hazard of wear.

Exaggerated diagrams showing development of Fast's principle of no flexible materials.



NO MATTER how carefully a flexible coupling is cared for and lubricated, to avoid wear it must be *permanently sealed* by a metal-to-metal contact, to prevent dust, grit, fumes and moisture from mixing with the oil.

Fast's Coupling is the flexible coupling with this metal bearing that assures perfect, grit-free lubrication at all times.

No make-shift, perishable materials that harden, dry out, or break are employed to seal Fast's Couplings. Metal bearing rings on metal hubs, machined to close tolerances, exclude grit and dust permanently and completely.

The side diagrams show how oil carries the load in Fast's Coupling. Note how it lubricates and cushions *between* the gear teeth. Oil—clean, fresh, dust-free oil—carries the load!

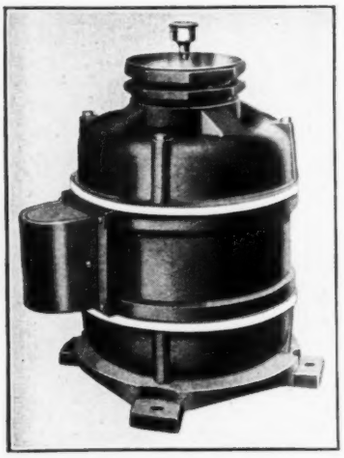
That explains why years of service have demonstrated that Fast's Couplings "last as long as the connected machines!"

FAST'S *Self-Aligning* COUPLINGS

PERMANENTLY DUST-PROOF

THE BARTLETT HAYWARD CO. ◆ SCOTT & McHENRY STS. ◆ BALTIMORE, MD.

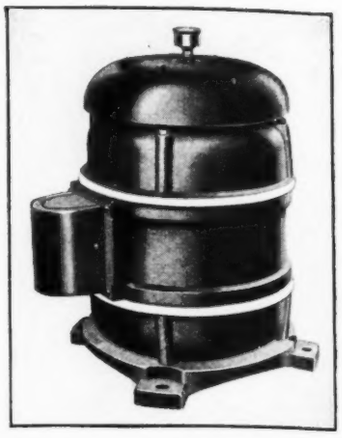
Red Band Adjustable Shaft Motor



AN adjustable shaft motor, which offers the pump manufacturer a motor having a fine micrometer adjustment, is being manufactured by the Howell Electric Motors Company, Howell, Michigan.

The adjustment of the shaft is accomplished by cast steel housing, accurately machined with 16 threads per inch. All adjustments can be made while the motor is in operation, carrying its full load at full speed. By placing a wrench on the micrometer adjustment, a "gallon per minute meter" on the pump and an amperemeter on the motor, it can be adjusted to maximum capacity of the pump at maximum efficiency of the motor per horsepower in not more than five minutes.

The lubrication chamber of the adjustable shaft motor is totally enclosed at all times while adjustments are being made. This prevents the possibility of injurious materials entering the housing or the ball bearings. The assembly is entirely separate from the protecting hood.



This new adjustable shaft feature is obtainable for vertical or horizontal motors, constant or multi-speed motors, and single phase or polyphase motors, and is built into the standard line of Red Band motors.

Petol Welding Tong

GEARENCH Manufacturing Company, 313-323 Hughes St., Houston, Texas, announces production and deliveries on its new Petol Welding Tong, a light, strong, chain-type tong designed especially for turning pipe, in either direction, on welding jobs.

The new tong is of the friction type, and has no teeth to cut or mar the pipe. Without being removed from the pipe, it turns pipe forward or away from the operator. In either direction, grip is instant and positive, and release is also quick and positive, the makers state. The tong cannot bind or "freeze" on the pipe so as to rotate it when being released.

The weight of the tong is carried on the pipe, making operation easy. They are furnished with exceptionally long handles for leverage and convenience. Jaws are made of one piece, eliminating spreading. Each size of jaw fits several sizes of pipe. Jaws are made in sizes to fit pipe from six-inch to 26-inch, and all jaws are interchangeable by removal of one bolt. Construction is of nickel chrome steel throughout. Heavy, special heat treated chains are furnished. Chain is easy to hook or unhook, chain hooking slots being integral with the jaws.

Petol Welding Tongs are furnished in three handle lengths, according to size of pipe to be turned.. Jaws are furnished in the following sizes: four-inch, six-inch, eight-inch, 10-inch, 12-inch, 14-inch, 16-inch, 18-inch, 20-inch, 22-inch, 24-inch and 26-inch.

Paul Arbon Hoist Series

PAUL ARBON & COMPANY, Tulsa, Okla., announce a new series of hoists, numbers 20C and 30C. Both series are flexible type with the 30C models designed for heavy-duty work, having extra power and flexibility, which, the makers claim, mean safety to load and to operator.

The power is derived from the tractor's power take-off through a link steel belt. The take-off has two speeds—one forward and one reverse. The gears are oversize cut, heat treated and run on ball bearings. The power take-off lever is ratchet-operated in all positions.

The drum is of one-piece electric steel, thoroughly annealed construction. The drum shaft bearings are heavy-duty bronze with the drum clutch of the jaw type, all steel and fully machined. The drum clutch, hand-operated, is not used except to give free spinning to the drum.

The 30C boom is of all-steel construction, with the height of the sheave eight feet above ground level. The boom has a radius that is adjustable from four to six feet from center of rear axle shaft.

Dixon Still Hose Coupling

THE Dixon Still Hose Coupling recently brought out by the Dixon Valve & Coupling Company of Philadelphia, is designed to meet all still hose requirements.

It is a compact, boltless coupling of the compression type, and when the sleeve is screwed up on the stem the three internal segments compress the hose and make a tight leakless connection.

As an extra precaution to prevent any possibility of the coupling blowing off, the end of the spiral wire winding on the hose is threaded through one end of the segments and bent back.

This coupling is made of malleable iron and furnished in three-fourth-inch and one-inch sizes.

Added PROTECTION

SHIELDED from the fiery rays of the sun—protected against sudden changes from the intense heat of day to the raw, shivering, cold of night—Parkersburg Vapor-Tight Tanks stand guard over costly contents, defeating the thief of evaporation.

Gas-tight tanks were pioneered by Parkersburg and perfected by Parkersburg improved valves. In active oil fields everywhere, Parkersburg Quality, Bolted Steel Tanks —Aluminum-Coated—equipped with Parkersburg Vapor-Pressure Fittings, bring definite economies by maintaining the gravity of the crude. In corrosive districts, Parkersburg all-aluminum, and aluminum-steel composite tanks, are successfully combating the corrosive effects of hydrogen sulphide.

Parkersburg is equipped to furnish Tanks in sizes ranging from 30 to 10,000 barrels from stock, in all the principal Mid-Continent and Gulf Coast districts, and efficient erection crews are in readiness at all times to answer any call for service.

A phone call to the nearest Parkersburg Branch will bring tanks and crews without delay.

FROM DERRICKS TO TANKS

QUALITY AND SERVICE

THE PARKERSBURG RIG AND REEL CO.

PARKERSBURG, W. VA.

NEW YORK • TULSA • FT. WORTH • HOUSTON

BRANCHES IN ACTIVE FIELDS

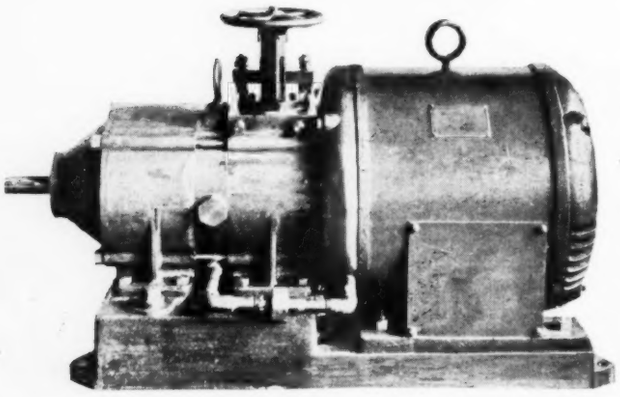
CABLE ADDRESS "PARIGREEL"

This Seal of Quality and Service on Parkersburg Equipment is Your Guarantee.

THE PARKERSBURG RIG AND REEL CO.

TRADE MARK REG.

A Variety of Speeds With New Electro-Hydraulic Transmission



THE American Engineering Company of Philadelphia announces the introduction of a small, very compact, 5 H. P. electro-hydraulic transmission. The transmission will develop full rated torque at any speed, whether it be 1 R. P. M. or 1,000 R. P. M., according to the makers. Since the torque is constant, the horsepower output varies with the speed of the hydraulic motor. At maximum speed the transmission will develop 5 H. P. continuously.

In the accompanying illustration the hydraulic motor is at the left, hydraulic pump next to it in the middle, and electric motor at the right. They are all mounted on a single bed plate reservoir which contains the oil used in the system. The entire transmission, including motor, is only 30 inches long, 14 inches wide and 16 inches high.

The hydraulic pump and motor are of the Hele-Shaw design and are similar in construction except that the motor has a fixed stroke, while the stroke of the pump may be varied from minimum to maximum.

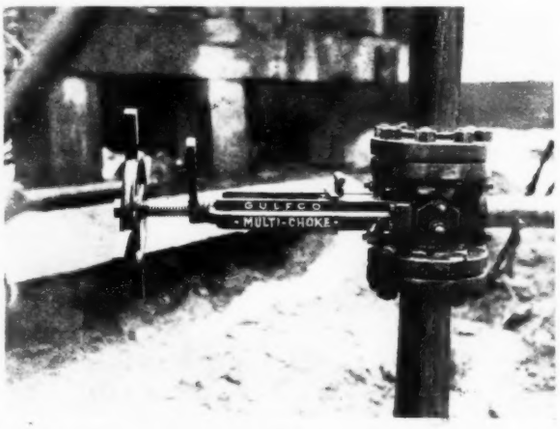
Pump and motor are multi-cylindered and handle the fluid in a smooth, continuous stream.

The electric motor drives the pump shaft at a constant speed. Oil is delivered by the pump to the hydraulic motor at a rate corresponding to the stroke of the pump, regulated by the hand wheel shown, or any other desirable hand or automatic control. This is the only point of regulation, for there are no controls on the electric or hydraulic motors. Through the handwheel the speed of the hydraulic motor can be varied all the way from zero to maximum in either a forward or reverse direction.

The pump end of the electric motor shaft is fitted with a fan. Oil in the system passes through finned tubing surrounding the fan, consequently its temperature is maintained at a degree commensurate with efficient operation.

Rapid Change Choke

THE Gulf Coast Machine & Supply Company of Beaumont and Houston, Texas, announces a new choke valve designed on an entirely new principle, the chokes being cartridges which are changed with almost the speed with which cartridges are ejected from a repeating rifle, the makers state. Each choke has five holes. A few turns of the handwheel changes from one opening to another; a matter of a few seconds.



Cartridges are furnished with any desired orifice up to one inch; either graduated in fractions, or series of uniform size holes. Body is made of heat-treated chrome nickel steel.

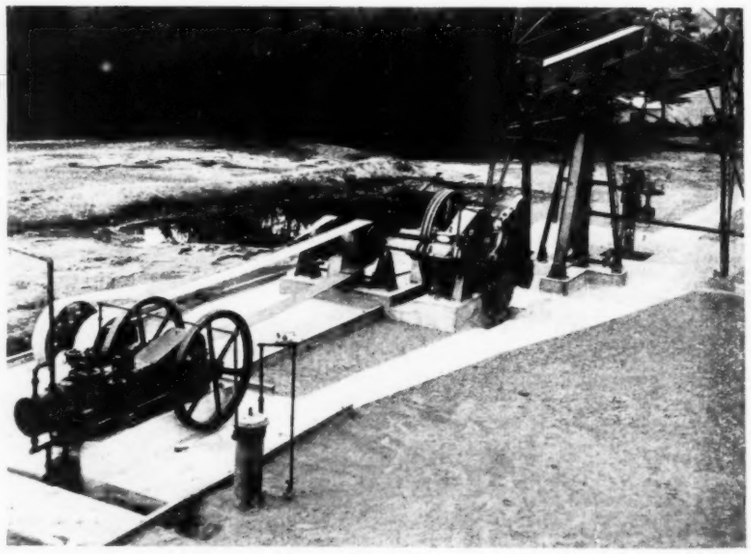
Lufkin Universal Geared Rig Front

LUFKIN FOUNDRY & MACHINE COMPANY, Lufkin, Texas, has designed a geared rig front for cable tool drilling and pumping that is adaptable to any type of prime mover.

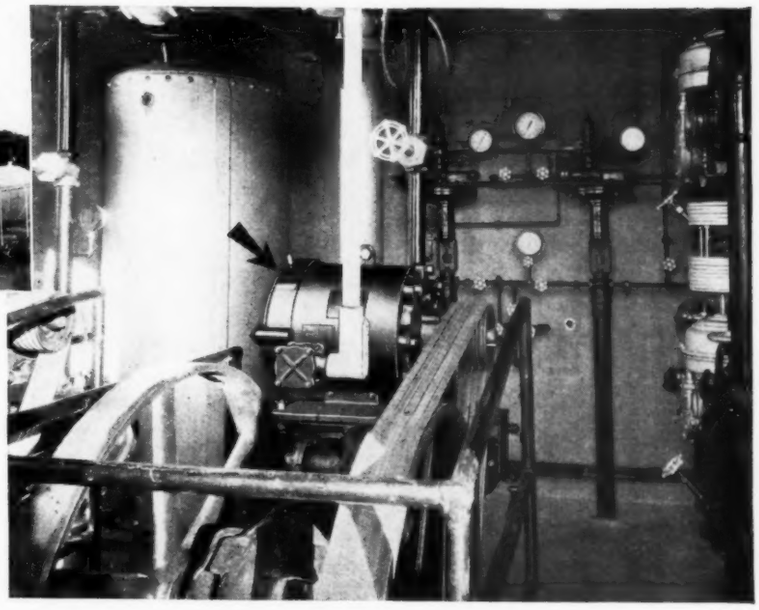
The gears used in the new Lufkin Rig Front are of the Sykes-Herringbone (continuous tooth) type. These gears are of a special alloy steel designed of generous proportion to insure lasting life under the most adverse operating conditions, according to the makers.

A feature of particular interest is the Trout-Croom Crank, which is used on the new unit. This crank is so designed that by a simple adjustment it may be made to "float" on an anti-friction bearing, leaving the crank free when servicing the wells.

A standard all-steel split 2-groove Tug Rim 7 feet in diameter is provided with the unit as is also a calf wheel sprocket with regular jaw clutch. These may be omitted however and a sprocket for production hoist added if desired. The Lufkin office will be glad to furnish additional information on the new geared rig front to those interested.



Skelly Oil Co. "bottled gas" or "liquid carburetion" plant at Spencer, Iowa . . . one of this company's many plants for making Skelgas . . . where 2 air compressors are driven by Louis Allis "Explosion-Proof" motors.



Bottled Gas Plant Protected *with* Louis Allis "*Explosion-Proof*" Motors

The *First* "Explosion-Proof" Fan-Cooled Motor...L.A. Type E

Tested and Approved by Underwriters' Laboratories for use in Class I, Group D hazardous locations, that is wherever petroleum products, alcohol, ethyl acetate, and equally hazardous liquids are made, used, or handled.

1/4 to 150 HP.

Here is one of the new and interesting "Bottled Gas" or "Liquid Carburetion" plants, that are now bringing gas service to many towns previously denied this modern convenience due to being located too far from sources of supply of natural or manufactured gas.

In this plant the finished gas is made from butane, a liquified petroleum gas, by vaporizing the liquid butane and carbureting with air from two compressors. The two compressors are equipped with Louis Allis Type E "Explosion-Proof" motors, because the designing engineer realized that in case of gas leaks the motors would be surrounded by explosive vapors. Consequently, the L.A. Type E motors *protect* this plant from the fire hazard incurred wherever non-approved motors operate in explosive atmospheres.

It was the L.A. Type E motor that first made possible the direct connection of approved motors to compressors, pumps, fans, centrifuges, unit heaters, etc., in explosive atmospheres . . . *without* the conventional fire wall. Now L.A. "Explosion-Proof" motors and starters are being used all over this country and in many foreign countries in chemical plants, oil refineries, natural gasoline plants, bulk stations, terminals, pumping stations, and dry cleaning plants.

Stop guessing at safety! Follow the leaders—*standardize* on Louis Allis "Explosion-Proof" motors and starters.

WRITE FOR COMPLETE INFORMATION

LOUIS ALLIS

"EXPLOSION-PROOF" *Electric* MOTORS

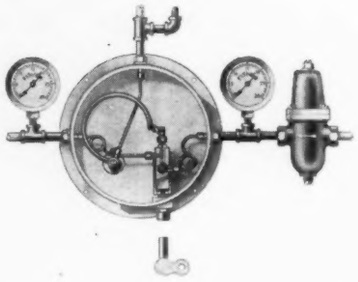
THE LOUIS ALLIS COMPANY
MILWAUKEE, WIS.

Motor Specialists Since 1901 — *Offices in Principal Cities*

Sales Offices: Tulsa, Houston, Shreveport, St. Louis, Chicago, Detroit, Cleveland, Pittsburgh, New York, Philadelphia, Boston, Buffalo, Los Angeles, San Francisco . . . and other principal cities.

Pilot Controller

THE latest addition made by Fisher Governor Co., Marshalltown, Iowa, to its line of specialty products is the new pilot valve control known as type 4,000. Full throttling or posted action is inherent, it being embodied into the construction and operation of this pilot. The elimination of all mechanical lag is another point of merit of this new device.

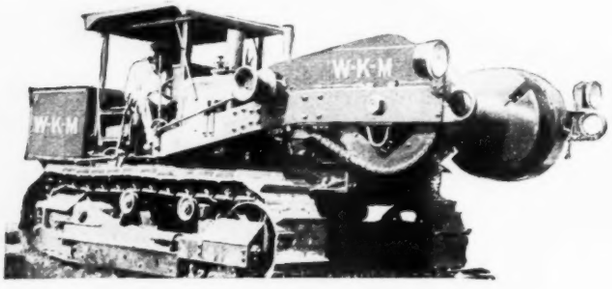


The change of the leak of the operating medium (air or gas) is accomplished by the varying position of the Bourdon tube which is a function of the pressure therein. This tube is suspended free in the control with the resultant elimination of all contacts and friction.

Flexibility in construction allows a change from direct action to reverse action in the minimum of time, thus changing a pressure control valve to a back pressure valve or vice versa without trouble or delay. A change in pressure range is made by a change of Bourdon tube. Any control unit can be changed from a low pressure control to any range up to 2,500-pound control pilot by fitting with a suitable Bourdon tube.

W-K-M Heavy Duty Winch

THE W-K-M Company, Inc., Houston, Texas, announces production and deliveries on a new W-K-M Winch, a heavy duty machine designed for mounting on the Allis-Chalmers "50" Track-Type Tractor. The machine incorporates features new in oilfield winch construction.

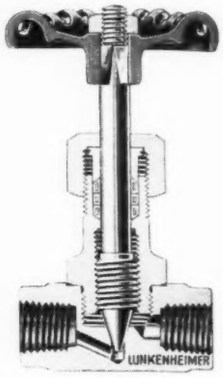


With a tubing line on the drum, the winch is designed so that normal center of gravity of the tractor is moved forward only 6½ inches. Special care has been taken to obviate the tendency to nose dive in rough going because of too much weight on the front end of the tractor.

The winch drive is from a heavy power takeoff at the rear of the tractor to a four-speed transmission mounted opposite the driver's seat for convenient gear-shifting. From the transmission, a heavy drive shaft fitted with universal joints carries power forward to a heavy duty bevel gear, which transmits the power to countershaft, located immediately in the rear of the drum.

Lunkenheimer Steel Needle Valves

THE Lunkenheimer Company, Cincinnati, Ohio, has developed two new steel needle valves for high pressure gas or liquid service. These valves are designed to give accurate throttling and regulation at pressures up to 3,000 pounds at 150 degrees F. The construction is exceptionally heavy with extra long pipe threads. They are for use on orifice meters for measuring gas and on other high pressure instrument lines.



The valves are identical in design, with steel body, hub, stem, stuffing box nut and gland. One has a bar steel body and is Parkerized and the other is made of stainless steel and is intended for use in localities where corrosive fumes are present in the atmosphere. Both patterns are made in ⅛, ¼, ⅜ and ½-inch sizes.

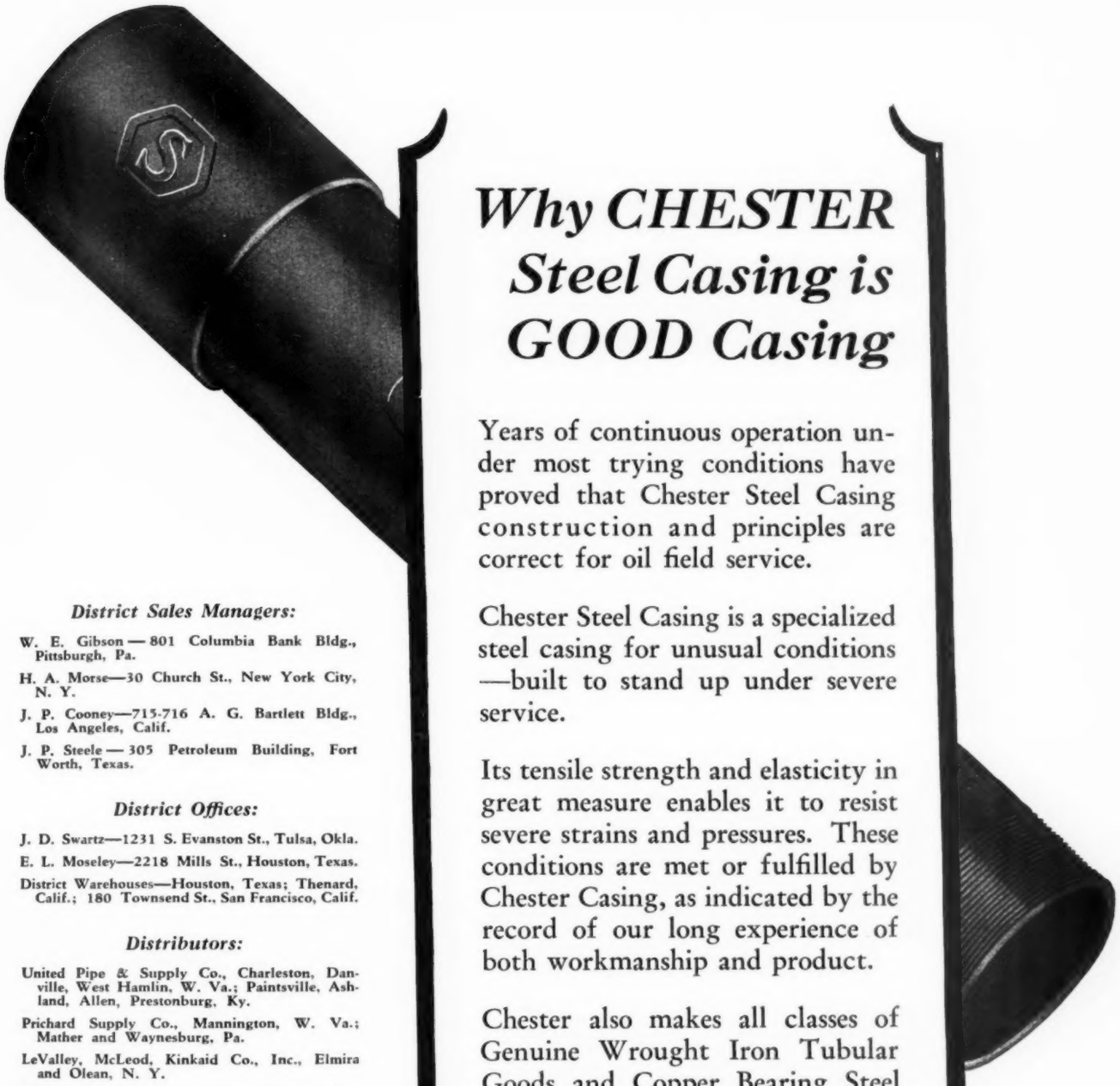
A copy of booklet F-548 illustrating these valves will be sent upon request by The Lunkenheimer Company.

Neilan Pressure Control Instrument

A NEW simplified pressure control instrument (non-recording type) has just been announced by Neilan Co., Ltd., Los Angeles, Calif., manufacturers of automatic regulating and recording devices. This new instrument is made to control pressures accurately in ranges from 0 to 5,000 pounds. It fills the need for a pressure controller where it is not imperative to make a chart record, the makers state.

The Neilan controller has been greatly simplified in design so that the average plant operator can easily adjust or repair it. It embodies such advanced features as the Neilan compound pilot valve and the sliding wedge actuating block which enables any degree of sensitivity to be obtained at any point on the instrument's pressure range. The case and many parts are made of duralumin which has the strength of steel combined with the lightness and corrosion-resistance of aluminum. To prevent corrosion certain internal working parts are machined of stainless steel.

A complete description of this new pressure control instrument is given in Bulletin No. 2,050, which may be secured by communicating with Neilan Co., Ltd., 641-651 Santa Fe Ave., Los Angeles, Calif.



Why CHESTER Steel Casing is GOOD Casing

Years of continuous operation under most trying conditions have proved that Chester Steel Casing construction and principles are correct for oil field service.

Chester Steel Casing is a specialized steel casing for unusual conditions —built to stand up under severe service.

Its tensile strength and elasticity in great measure enables it to resist severe strains and pressures. These conditions are met or fulfilled by Chester Casing, as indicated by the record of our long experience of both workmanship and product.

Chester also makes all classes of Genuine Wrought Iron Tubular Goods and Copper Bearing Steel Pipe.

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Kane Supply Company, Kane, Lawrenceville, Brookville, Pa.

Pelican Well Tool & Supply Co., Shreveport, La.; Kilgore, Texas.

Louisiana Iron & Supply Co., Shreveport, La.; Henderson and Kilgore, Texas.

United Oil Well Supply Co., 712 A. G. Bartlett Bldg., Los Angeles, Calif.

Great Northern Tool & Supply Co., Billings and Kevin, Mont.; Kemmerer and Cody, Wyo.

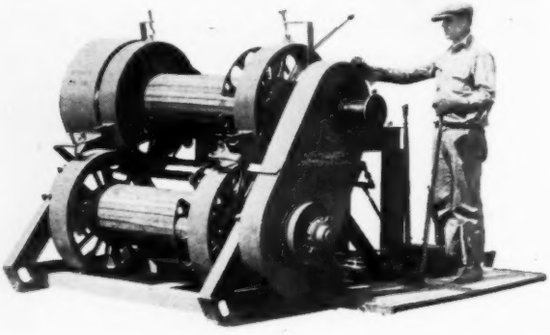
CHESTER

STEEL SPECIALISTS IN CASING FOR DEEP WELL DRILLING **CASING**

LINE **PIPE**

Oilfield Skid Type Winches

THE manufacture of three new skid models of winch well-servicing units has been announced by The All-steel Products Manufacturing Company, Wichita, Kan. The two larger units, Models ES-50 and ES-100, will be supplied in either double or single drum models, while the smaller unit will be provided in single drum model only.



These skid type winches are highly mobile; fast, flexible and economically operated as well-servicing and reclamation units, adaptable to either electric or gasoline power. The larger unit will be exactly similar to the ES-50 Double Drum Skid Winch shown in the accompanying picture, except that it will accommodate a much larger motor or internal combustion engine. The other unit is a smaller one, designed for operation with Ford or Chevrolet motors or the motor assembly from "Caterpillar" Tractor Model Twenty, or other similar power units.

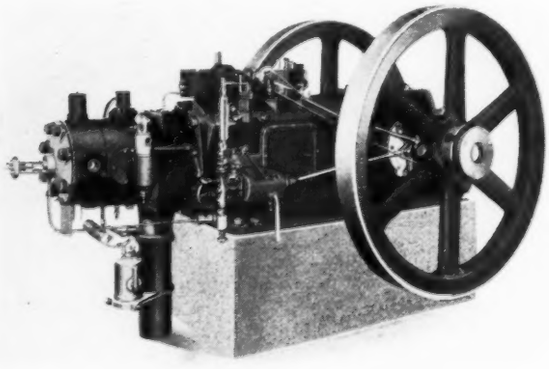
Specifications may be obtained from the manufacturers.

Pumping and Drilling Engines Convertible for Oil Fuel

COOPER-BESSEMER CORPORATION, Mt. Vernon, Ohio, announces that present and earlier models of Cooper-Bessemer pumping and drilling engines can now be equipped for burning oil fuel.

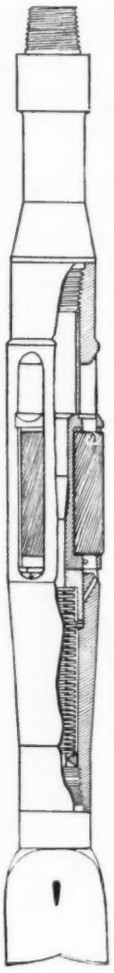
In the case of the new two-cycle engines (Types GA and OF), they can be factory-equipped for oil burning. Gas engines now in the field can be quickly converted by use of a replacement cylinder head, fuel-oil pump, and other necessary parts. Such oil-fueled engines can, of course, be converted back to gas at any time.

The new cylinder head looks like the gas-engine head. It has a somewhat smaller clearance to give the necessary high compression, and the large hot tube is on the bottom. Fuel-pump valves and by-pass are hardened-and-tempered drop forgings with ground finish on all working surfaces. They operate in removable seats of the same quality. The spray valve is of the spring-loaded differential plunger type, suitable for variable speed work and heavy fuels.



In the case of four-cycle (Type FC-E) gas engines now in the field, conversion of the 30 and 40 horsepower sizes is accomplished most economically by substituting two-cycle cylinders with oil-burning heads.

Grant Rotary Expansion Underreamer (Left)



THE Grant Oil Tool Company has introduced the Grant Type "C" Rotary Expansion Underreamer, of particular interest to operators in that it is really two tools in one. According to the makers, it can be used as an underreamer or as a straight reamer—the change being effected by the substitution of a cutter control collar for the upper sleeve. This feature requires the purchase of only one tool to do two jobs—reaming or underreaming.

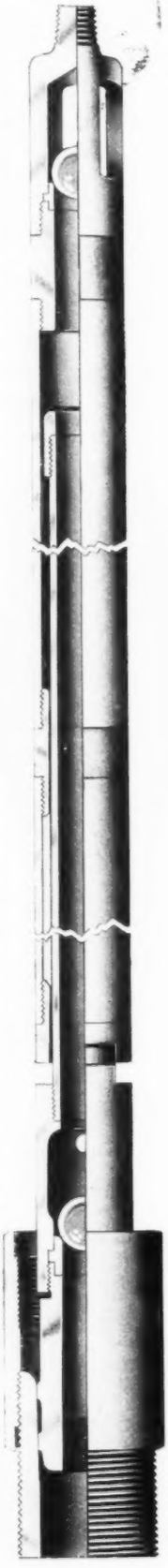
Full particulars of this new tool may be secured from the Grant Oil Tool Company, Los Angeles, Calif.

Insert Pump by Hopper Machine Works (Right)

AN INSERT pump with a ground liner and plunger has been placed on the market by the Hopper Machine Works, Inc., of Bakersfield, Calif. Being of the insert type it is removed with the rods and does not require the pulling of tubing. Manufacturers claim that the pump is particularly advantageous in small producing wells of 200 barrels or less per day and also for wells making sand or other abrasive deposits with the oil.

The pump has the marked feature of a plunger six feet long, ground its entire length and working with a cast iron liner ground to ten-thousandths of an inch. This permits the pumping of oil containing considerable sand and foreign matter. The liners are bored to the largest possible size in new pumps to permit the plunger several regrinds. The liners used with these smaller plungers are then reground to the larger or new plungers.

Two sizes are available at the present time: the 2½-inch and the 3-inch. The stroke is 48 inches. The balls and seats are the best obtainable, according to the makers, and all cages and fittings are made according to A. P. I. standards.



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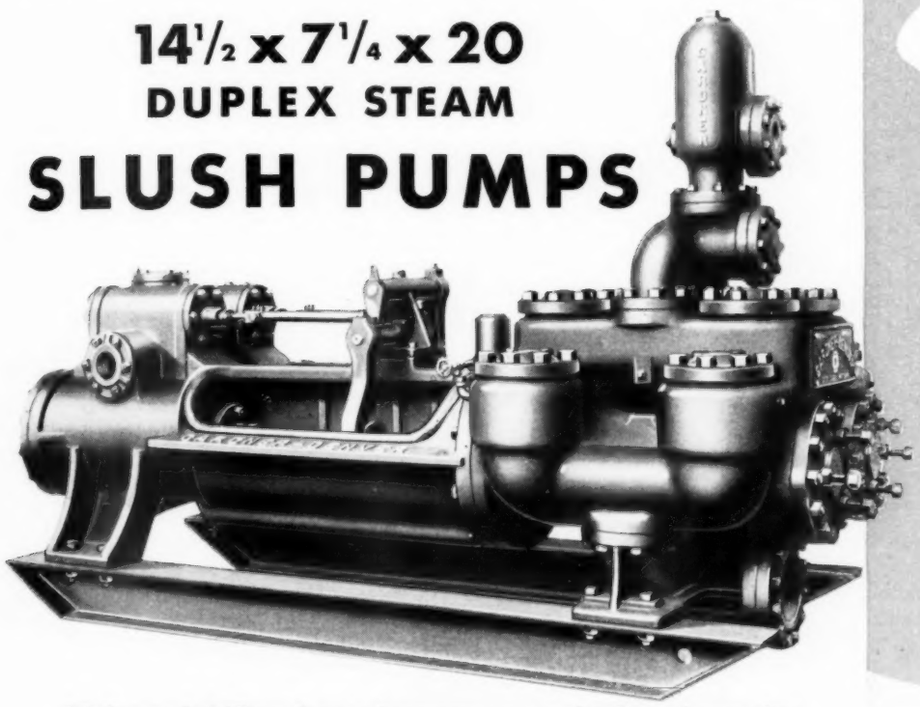
DUPLEX STEAM
SLUSH PUMPS



High speed drilling, low maintenance cost and safety of operation account for the outstanding performance records of Gardner-Denver Slush Pumps..¶In the Fort Morgan area, Greasewood Dome, Colorado, a well-known contractor recently drilled 2340 feet in 24 hours, using Gardner-Denver 14½x7¼x20 Duplex Steam Slush Pumps..¶Such dependable performance is assured by these features: More fluid, longest stroke, divided fluid end, rugged cradle and steam piston valves.

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FE-11-GRAY

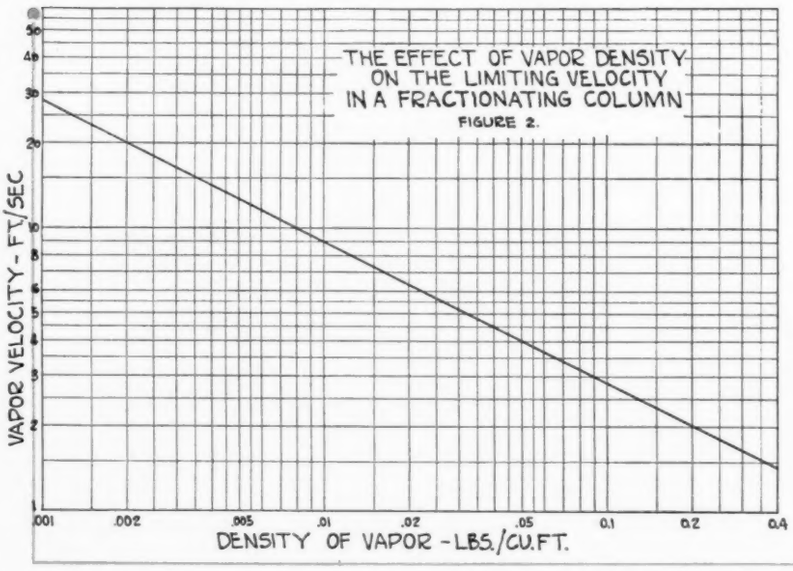
CONTINENTAL

The Fractionation *of* Heavy Oils

Article III: Number of Plates and Diameter of Column

By W. L. NELSON[1] *and* DR. MOTT SOUDERS, JR.[2]

THE two preceding articles of this series dealt with the fundamental principles of fractionation[1] and the application of heat and material balances to the fractionating column.[2] The present discussion takes up the variables involved in, and the status of the methods available for the calculation of the number of plates required, and the factors which determine the diameter of the column.



Number of Plates

Calculation of Theoretical Plates Required

As has been pointed out before, petroleum oil fractions are exceedingly complex systems probably involving hundreds of compounds. This fact makes the direct application of equilibrium equations, involving the vapor pressures and mol fractions of each component, hopelessly involved if not impossible.

Several attempts have been made to employ simplifying assumptions which would reduce the complex system to the essential mechanism of a binary mixture and thereby permit of a practicable calculation of the number of theoretical plates required for a definite separation of components. One of these methods[3] consists of (a) selecting a narrow boiling fraction near the "cut point" between the fractions separated, (b) treating this as an ordinary component with the same average volatility as a pure hydrocarbon of corresponding boiling point and calculating the number of plates required to secure a satisfactory distribution of the arbitrary component between distillate and residue, by the application of material balances and equilibrium relationships from plate to plate.

This method is unsatisfactory because the calculated result varies with the fraction chosen as the arbitrary component.[4]

Another method which has been proposed[5] employs graphical integration of an equilibrium equation applied to the true boiling point curve of the vapor distillate (or liquid residue). The liquid (or vapor) in equilibrium with the material represented by the true boiling point curve is calculated and the analysis is continued from plate to plate down (or up) the column until a residue (or distillate) of the desired composition is produced.

Because errors in composition are cumulative in working from one end of the column to the other and because the calculation is tedious, this method has not proved satisfactory for practical calculations.

As yet no adequate method for calculating the number of theoretical plates required in the fractionation of petroleum oils has been published.

Plate Efficiency

In general, plate efficiency may be defined as the ratio of the performance of an actual plate to the performance of some ideal plate. According to the definition commonly accepted,[6] plate efficiency is the amount of a given component in the ascending vapor which is absorbed by the liquid upon the plate divided by the amount which would be absorbed were equilibrium actually attained.

A thermal definition may also be employed wherein plate efficiency is the heat actually removed from the vapor passing through the plate divided by the heat that would be removed were equilibrium actually attained. (At equilibrium the temperature of the vapor above and of the liquid on a plate are equal, whereas with an actual plate the temperature of the vapor is higher than the temperature of the liquid.)

The "ideal plate" tacitly assumed in equilibrium equations is one where all the vapor from the plate below contacts liquid of constant composition from the plate above and is in equilibrium with the liquid overflowing to the plate below. That is, this "ideal plate" assumes a single equilibrium contact per plate.

Plates in an actual column, however, usually involve a number of successive contacts per plate. The liquid changes composition progressively as it flows across the plate, so that the vapor flowing through each successive row of caps approaches equilibrium with a liquid of different composition. Even if equilibrium were attained at each contact, the composition of the vapor leaving the plate would be considerably different from the composition of the vapor in equilibrium with the liquid overflowing from the plate.

It has been shown[7] that the successive contact plate upon which equilibrium is attained at each contact produces a greater change in the composition of the vapor passing through it (i. e., is more "efficient" under ideal conditions) than does the usual "ideal plate" involving a single equilibrium contact. This concept may account for some of the apparent plate efficiencies greater than 100 per cent that have been reported with apologies in the literature.

[1] Professor of Petroleum Engineering, University of Tulsa.
[2] Consultant Engineer, Ann Arbor, Mich.

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The latest process developments use ALCORN FURNACES

LESS INITIAL COST
LESS MAINTENANCE
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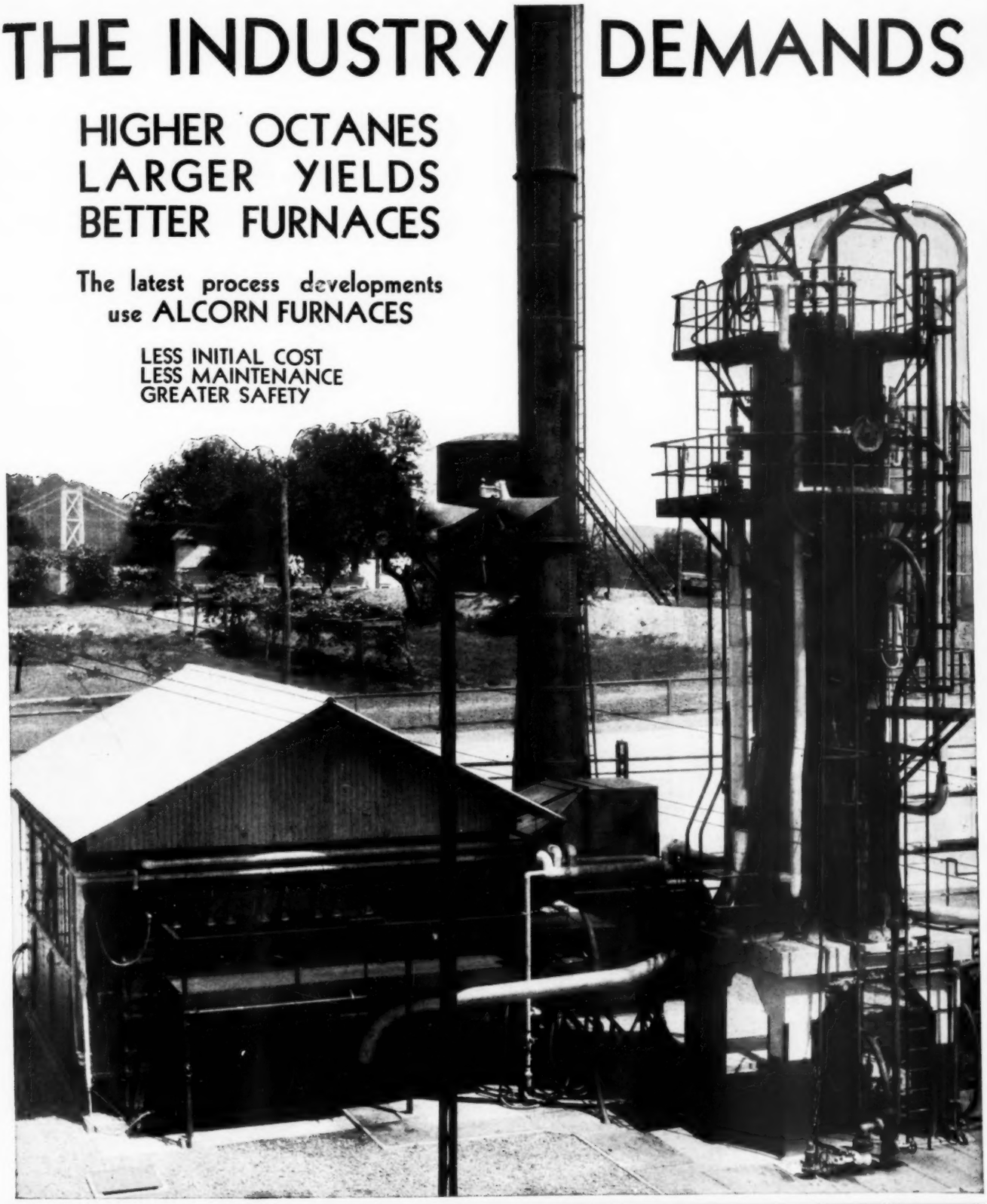

THE ALCORN COMBUSTION COMPANY

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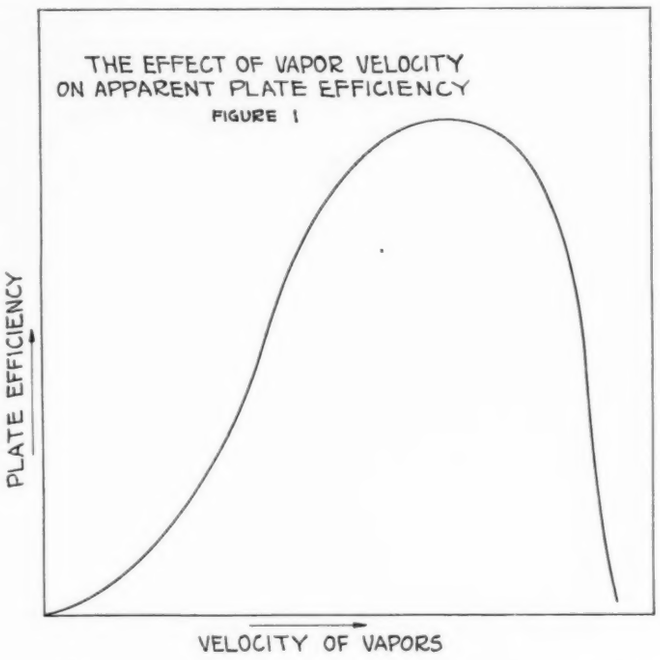
TULSA OFFICE
Court Arcade Bldg.

LOS ANGELES - SAN FRANCISCO
California Representative
Pacific Abrasive Supply Co.

HOUSTON OFFICE
Petroleum Bldg.

It appears that, other things equal, the plate which provides the greatest number of equilibrium contacts should be the most efficient. In other words, the liquid should flow over the plate from inlet to outlet by the longest possible path. However, the longer the path of liquid flow, the greater is the hydrostatic gradient across the plate. Thus the length of the path of liquid flow involves a compromise between plate efficiency and hydrostatic gradient across the plate.

In vacuum columns the problem of hydrostatic gradient is particularly important because the diameter of the column is large and pressure drop through the plate must be kept at a minimum. For this reason vacuum plates are sometimes built with a series of cascades or levels with an overflow dam between each cascade to redistribute the liquid. At atmospheric pressure or above, the hydrostatic gradient does not present unusual difficulties, unless exceptionally large quantities of liquid must be handled, so that the plate may be designed for a maximum liquid path.



THE EFFECT OF VAPOR VELOCITY ON APPARENT PLATE EFFICIENCY
FIGURE 1

In general, plate efficiency may be regarded as the resultant of two distinct and opposing effects. One of these is the approach to equilibrium between liquid and vapor while the other, the entrainment of liquid by the vapor, tends to destroy the attainment of equilibrium.

Some of the more important factors in plate efficiency may be outlined as follows:

1. Definition of plate efficiency.
2. Number of successive contacts per plate.
3. Approach to equilibrium conditions, involving
   a. Intimacy of contact between liquid and vapor and dependent upon
      (1) Extent of vapor-liquid surface of contact,
      (2) Agitation which aids the diffusion process in both phases;
   b. Velocity of vapors through cap slots and tower shell,
      (1) Influencing the vapor-liquid surface of contact,
      (2) Affecting agitation;
   c. Difference in composition between liquid and vapor phases, which affects the rate of mass transfer;
   d. Time of contact between vapor and liquid.
4. Entrainment, which in turn is influenced by
   a. Velocity of vapors through slots and shell,
   b. Density of liquid and vapor,
   c. Plate spacing.

Thus, it appears that plate efficiency is an exceedingly complex phenomenon. It varies with the mechanical details of plate and column construction, with vapor velocity and density, and with the properties of the oil. Plate efficiencies vary not only among various fractionating towers, but differ from plate to plate in the same column. The over-all apparent plate efficiency is of doubtful significance and is often misleading.

Number of Actual Plates Required

Because of the difficulty in predicting plate efficiency and the tediousness and unreliability of the present methods of calculating the number of theoretical plates required, a satisfactory method for calculating the number of actual plates required for the fractionation of petroleum oils is yet to be developed.

At the present time the selection of the number of plates for a new column is based largely on plant experience. Considering the complexity of determining the exact number of plates, no apology is necessary for the empirical method of estimating the number of plates. Furthermore, since the operating capacity of a plant usually varies widely, it is doubtful whether it is feasible to compute and install the exact number of plates required for a separation. Nor can a factor of safety be applied to such a calculation, because the plant would probably operate below and above capacity as much of the time as it would at the proper rated capacity. The current trend among the leading designers appears to be toward a larger number of plates between fractions.

The table below lists the number of plates which have been employed between fractions in several columns recently erected.

The use of the separating plates involves the use of auxiliary stripping columns or plates. A satisfactory separation at the high boiling-point end of the fraction is usually obtained from the column directly, but the front end of the distillation curve is usually adjusted by steam-stripping plates.

Type of Plant	No. of Plates (Trays at 20")	Between Fractions
Steam Atmospheric	6	Gasoline and Kerosene
	5	Gasoline and Naphtha
	4	Naphtha and Kerosene
	4-5	Kerosene and Gas Oil
	7	Gas Oil and Wax Distillate
	4	Stripping Plates
Cracking	9	Pressure Distillate and Recycle
Cylinder Stock Solution	4-5	Naphtha and Gas Oil
	5	Gas Oil and Neutral
	5	Neutral and Feed Plate
	4	Stripping Plates
Vacuum Lubricating Oil	4-5	Gas Oil and Wax Distillate*
	10	Wax Distillate and Overhead Cyl. Stock
	5†	Wax Distillate and Overhead Cyl. Stock

* Often separated by partial condensation.
† At wide tray spacing.

Diameter of Column

Vapor Velocity

Under the discussion of plate efficiency the effect of the velocity of the vapor through the free space of the column

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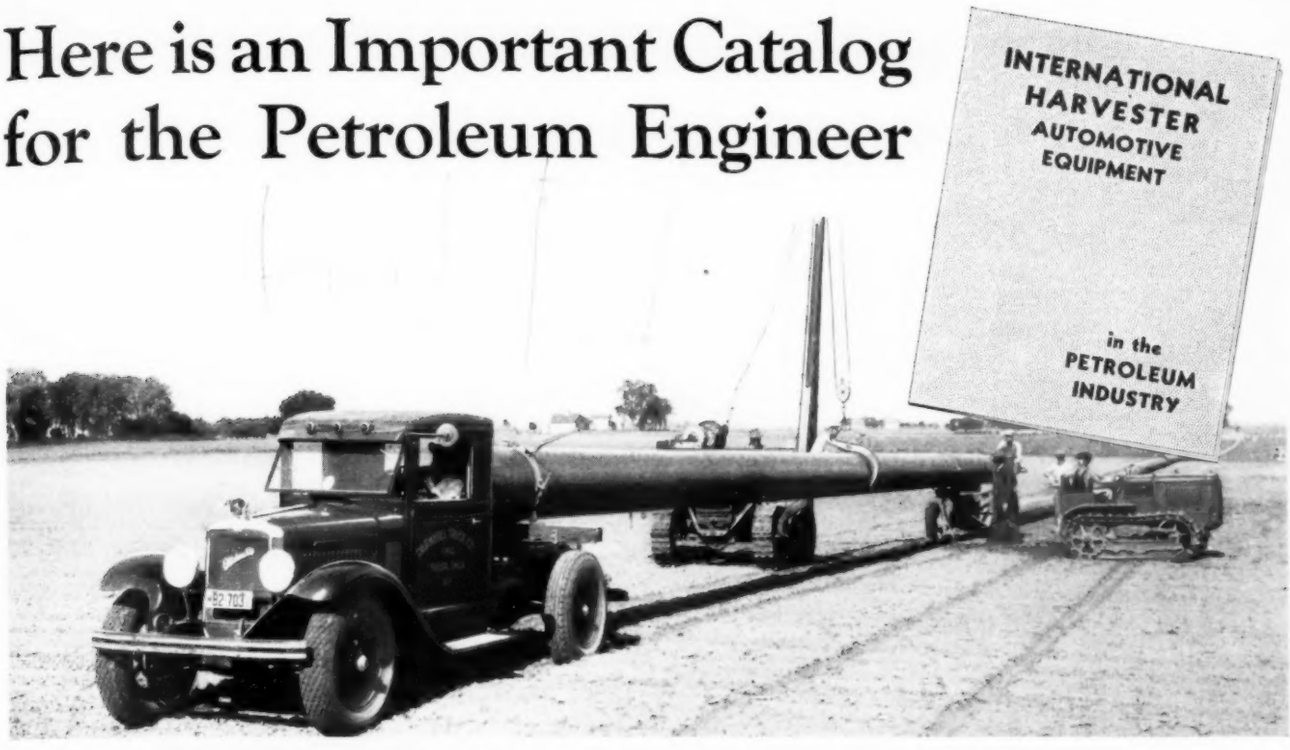

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was indicated. In general, higher mass velocity of the vapor promotes the attainment of equilibrium through the greater agitation and larger vapor-liquid surface of contact provided. On the other hand, higher mass velocity increases the tendency of the vapor to carry droplets of liquid upward from one plate to the next.

It appears that the velocity of the vapor in the column influences the two components of apparent plate efficiency—(1) approach to equilibrium and (2) entrainment—in opposite directions. Hence there should be an optimum vapor velocity under any fixed set of operating conditions which will produce the maximum plate efficiency.

Figure 1 shows in a general way the effect of vapor velocity on plate efficiency. Increasing the velocity of the vapor increases the apparent plate efficiency until the entrainment of liquid droplets overbalances the agitation effect. Further increase in vapor velocity causes a rapid falling off of the apparent plate efficiency.

The tendency of a vapor to entrain liquid droplets is a function of the diameter of the droplet and the densities of the liquid and vapor.[8] If the density of the vapor may be assumed to be negligible with reference to the density of the liquid, and if the diameter of the droplets or the density of the liquid† may be regarded as constant, the entraining velocity may be evaluated by

$$v = \frac{k}{\sqrt{d}}$$

v = entraining velocity ft./sec.
d = density of the vapor—lbs./cu. ft.
k = a constant to be evaluated from operating data.

The entraining velocity, v, represents the limiting velocity of the vapor through the free space between the plates of a fractionating column.

The constant, k, has been evaluated from data on a number of columns operating near their capacity. For columns processing heavy oils, taking overhead products ranging from gasoline to gas oil, the value of k was found to be about 0.9.

The equation, $v = \frac{0.9}{\sqrt{d}}$, is plotted in Figure 2. This curve represents the practical limiting velocity of vapor through the free space of the column.

The velocity of the vapor through the slots in the caps is also of importance in column design. Usually a high slot velocity promotes agitation and aids in the attainment of equilibrium. Excessive slot velocity, however, causes liquid droplets to be thrown too high and increases entrainment unless the distance between plates is increased. High slot velocity also increases the pressure drop of the vapor flowing through the caps. This is a consideration of importance in vacuum column design. In commercial atmospheric columns the slot area is approximately 12.3 per cent of the column area. Normally the pressure drop per plate for atmospheric columns is 0.2 pounds per square inch.

The greater the distance between plates, the smaller will be the amount of liquid thrown by bursting bubbles which reaches the chimneys leading to the plate above. Moreover, a wider plate spacing allows more time for the agglomeration of small droplets into larger ones which are less readily entrained.

With common bubble trays operating at normal capacities, the percentage of entrainment at a twelve-inch spacing is about twenty-five times the entrainment at a twenty-two-inch spacing. In fact, many designers have found that better fractionation resulted when every other plate of a closely spaced column was removed. Chillas and Weir[9] report that with a sixteen-inch spacing the entrainment at a velocity of two feet per second was negligible, but that at four feet per second and 5.5 feet per second the entrainment is 7 per cent and 20.5 per cent, respectively. Usually the plate spacing which is selected involves a compromise between the cost of increasing the height of the column and the cost of increasing the diameter to secure a lower vapor velocity. In many cases decreasing the vapor velocity requires the use of a larger number of plates (because the plate efficiency is decreased), so that a relatively wide plate spacing is usually desirable.

Throughout this discussion of entrainment and vapor velocity the ordinary bubble plate without baffles has been under consideration. The use of baffles or other devices to remove entrainment naturally permits of much higher vapor velocities.[9] However, the cost of such devices and the difficulties with corrosion have been deterrents to their use.

Internal Flow of Liquid

The Francis weir formula, although it is not strictly applicable to small liquid heads, is usually employed to indicate the approximate weir length required. The Francis formula is

$$Q = 3.33\ l\ h^{3/2}$$

where Q = Discharge in gallons per minute
l = Length of weir in inches
h = Head of liquid in inches

The weirs should be designed separately for each section of the column, since the quantity of liquid handled varies widely from top to bottom of the column.

Where the quantity of liquid is small, the weirs should be constructed with V notches to secure adequate distribution of liquid. The formula for V notched weirs is

$$Q = 1.2\ l\ h^{3/2}$$

Downpipes carrying liquid from one plate to the plate below should be of ample capacity. For circular downpipes the orifice formula is usually employed,

$$Q = 4.4\ A\ h^{1/2}$$

where A = the cross-sectional area of the pipe in square inches.

It is advisable to use an area equal to four times the area calculated by the formula, since the liquid flowing is at its "boiling point" and may be largely froth.

The proportion of the plate area required for weirs and downpipes has a bearing on the diameter of the plate and column. If the diameter of the plate, selected on the basis of the limiting velocity through the shell (Fig. 2), does not provide space for the weirs and downpipes without crowding the caps or requiring an excessive slot velocity, the diameter of the plate must be increased accordingly.

† From 38 different sets of plant data the average density of the liquid on any plate of a tower was found to be 42.7 pounds per cubic foot. The value is accurate within plus or minus 6 per cent.

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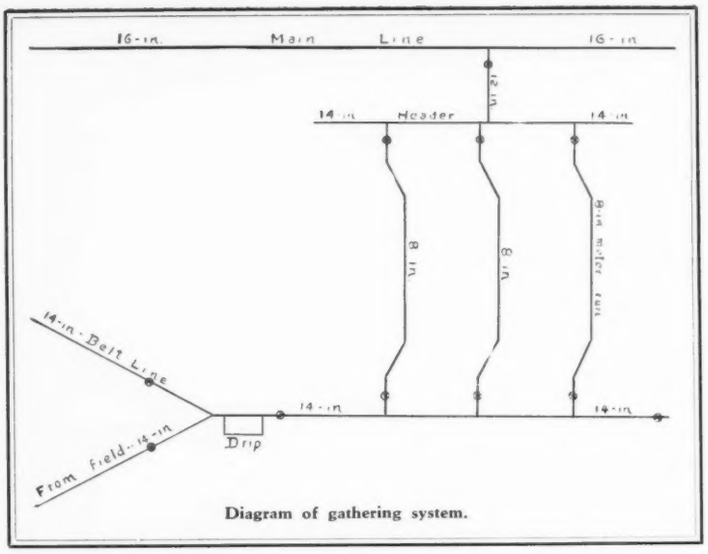


Diagram of gathering system.

LARGE GATHERING SYSTEM *for* HUGOTON GAS FIELD

UPON the completion last summer of a 52-mile main line belt system and 96 miles of branch feeder lines, the Hugoton gas field in southwestern Kansas was afforded its first large-volume outlet. The gathering system was built for the Argus Production Co. and has a capacity of 43,000,000 feet daily at present. Deliveries are made to the Panhandle Eastern Pipe Line Co., to a 16-inch line the transporter built to the field from its Liberal (Kansas) station. Panhandle Eastern Co. has completed a 24-inch, 22-inch and 20-inch welded and coupled gas transmission system from the Texas Panhandle to Indianapolis, Ind., and is in position to draw gas from two of the nation's largest gas reserves.

Argus Production Co.'s gathering system was built by Knupp & Fredell, pipe line contractors. The main belt line, looping the area from which gas is drawn, consists of 52 miles of 14-inch. The 96 miles of branch or feeder lines is comprised of 8-, 6-, 4-, 3- and 2-inch pipe.

The pipe order for the gathering system was divided as follows:

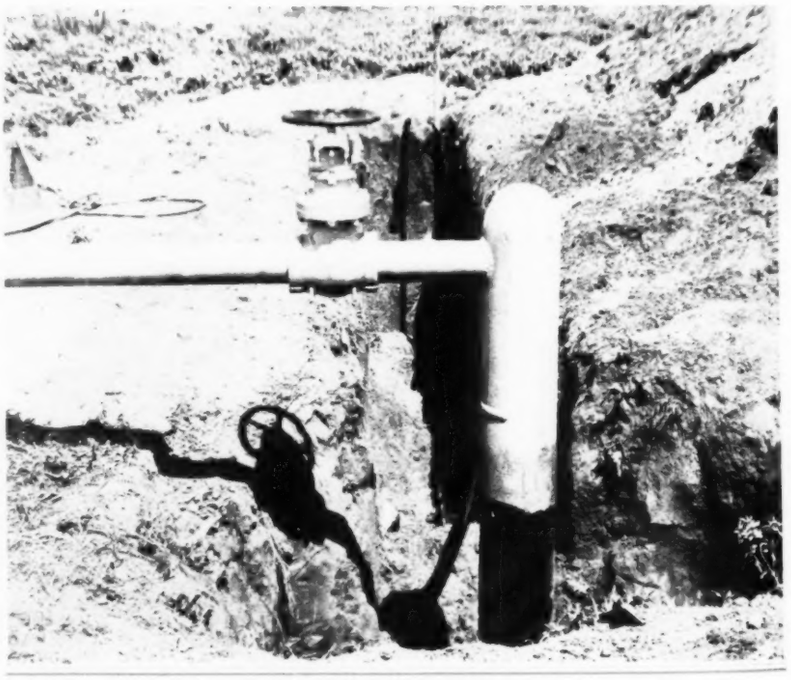
Diameter	Amount
14-inch	274,919 feet
8-inch	17,160 feet
6-inch	153,200 feet
4-inch	229,313 feet
3-inch	102,085 feet
2-inch	6,600 feet

Although expansive, because of the conservative method which this part and other parts of the Hugoton area are drilled, with one well to each 160 acres, the system will be simple in operation. The 14-inch line makes almost a perfect circle in looping its section of the field. The wells in the area average 7,000,000 feet open flow capacity per well and the average rock pressure of the wells is 435 pounds.

The rock pressure average does not have a variation of more than two or three pounds, making it a comparatively easy task to handle the individual wells flowing into the belt line. Each well will either be regulated by valve control or by orifice plates at the well meter settings.

The producing company has adopted a standard method of building feeder lines from the wells to the main belt line. Coming from the well, the line goes into a heater. These are made by welders at the company's warehouse in Hugoton. It consists essentially of a barrel extending several feet along the line and has two vent pipes extending above the surface. Plates have been welded in the two ends and openings cut to permit the line pipe to pass through and to provide for the burner in the other end.

Before going to the individual recording meter the gas passes through a water knockout. This is made by welders by bull plugging one end of the pipe. The pipe is cut in orange peel shapes, hammered into a plug shape and then welded. A baffle plate was inserted in the knockout near the top. All water and foreign material drops back and goes into a trap set at a 90-degree angle from the knockout. The trap is buried in a sloping ditch to permit all foreign material to collect at one end. The accumulation may be blown off through a bleeder line extending from the deeper end of the trap to the surface.


Water knockout and drip.

After going through the trap the flow line runs along above the surface to the meter house. The meter houses are all timber frames covered with sheet metal. They are all large enough to permit repair or adjustment being made to the meter inside the house. One window is provided. With such an installation, charts may be changed during inclement weather without risking having them damaged by water or wind.

After leaving the meter run the line goes to a check valve located behind a gate valve. The swing check will prevent gas under greater pressure backing through the meter or to the well. From there the line ties into the main belt system.

Wherever possible all of the meter houses are located close to the section roads to facilitate the chart changer's work. In most instances the meter house is enclosed with a high fence and a lock is provided for the gate to prevent tampering with the installation.

The two ends of the 14-inch belt line tie into a 14-inch header at the measuring station located at the delivery point to the transmission company. At the head end of the header another drip was installed to remove any moisture or foreign material that passed on through the knockouts at each well. The meter runs consist of 8-inch pipe which tie into a 14-inch header from which the gas flows through a 12-inch line on into the 16-inch main line.

Because the maximum pressure to handle is around 435 pounds, and the belt line will readily carry that pressure, no elaborate regulation layout is necessary. The gas will be delivered to the transmission company at about average field pressure.

All of the meter settings and the construction of the main measuring station was done by the producing company. All of the valves and fittings used are high-pressure installations.

In some spots the work was spragged because the sand was dry and there is little vegetation growing. In such spots the going was a little slower and more care was taken to dig a clean trench wide enough so the welding and laying crews would not knock sand and dirt in the trench to the extent it would have to be shoveled out. So far as wear and tear on the machine is concerned, it has not been as rapid as expected because of the cutting action of the sand. For the most part the wind blew the sand away from the ditcher and, by carefully watching its lubrication, wear was minimized.

Because of the sparse growth of vegetation it was not necessary to use brush gangs to clear the right-of-way. This also made stringing a comparatively easy task. Trucks with trailers, lightly loaded, were used to string the pipe from the rail points only a few miles from the furthest point along the line.

The pipe was shipped in 40-foot lengths and welded in five joint sections. The firing line welders worked with a battery of four generators. These were moved along the line with teams.

Heater assembly in ditch ready to be tied into line.

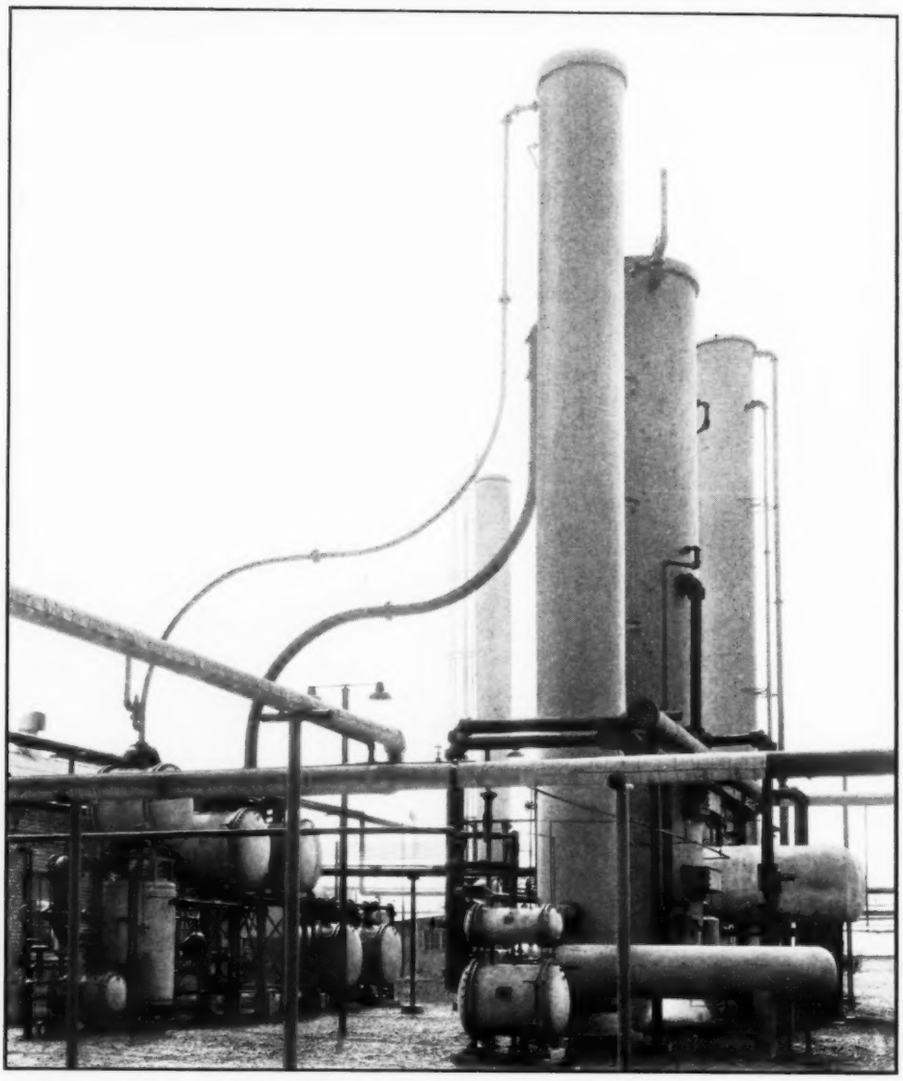
The water for the generators was supplied by a truck which had a tank mounted on it. The open water supply was limited and most of it was hauled from an ample supply in Hugoton. Fuel for the machinery was also supplied by a truck making frequent trips over the entire job.

In welding the sections the pipe was lined up on skids on the side of the ditch. The welders' helpers turned the pipe with chain tongs as the roll weld was made. Sections of the line were tested as they were completed, and upon completion the entire line was blown with gas to purge it of air and dust.

Working some distance behind the firing line, the bell hole welders and laying crew tied in the completed sections. All of the bends were made cold. They usually consisted of easy overbends and sags and ordinarily one tractor was used to make the bend. Heavy-duty tractors were used because their work is more smooth in the sand than a lighter machine. Ample slack was left in the line to care for contraction and expansion and most of the lowering was done during the early morning hours.

To protect the line from corrosion all of the pipe was coated with a cold application of paint.

The producing company built its own lines from the wells to the meter house and did considerable of the lateral work. The trenching for these lines was mostly done by hand. All of the ditching work in connection with the heater and water knockout construction was done by hand.



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High Temperatures Bring About Unusual Drilling Conditions *in* New Colorado Pool

DRILLING conditions in the newly discovered Greasewood Dome or Platte Valley field of Weld and Morgan counties, Colorado, which promises to become an active area, are very interesting, principally because of the unusually high temperatures encountered, which occasion considerable difficulty and delay in cementing casing and also in drilling operations.

The bottom hole temperature of the oil runs as high as 212 degrees F., but at the casinghead is only about 60 degrees F., the difference being due doubtlessly to the cooling effect of the gas expanding from high to low pressure. In cementing the casing on the Reiter-Foster Oil Corporation's Ida Johnson No. 1, abundant trouble was experienced owing to unexpected excessive temperatures which caused the cement to set quicker than anticipated, with the result that 4,000 feet of cement was left in the casing.

This cement was drilled out with rotary tools, and took three weeks. In the later wells drilled in this field, several tons of ice have been mixed with the cement in attempting to overcome the effects of the high bottom-hole temperatures. Opinion among field men varies widely as to what extent the ice affects the temperature of the cement slurry at so great a depth, but as the difficulty seems to have been overcome, the practice is still being followed.

In drilling the Ida Johnson No. 1 well the high temperature affected the regular type rock bit. It caused the oil to escape from the bushings, thereby resulting in excessive wear. The drilling contractors, Manning & Terry, Inc., of Tulsa, then changed to a new type rock bit with special bearings that did not require oil.

The original well on the structure, Platte Valley Oil Company's Patterson No. 1, was drilled with standard tools. But on the second well, Reiter-Foster Ida Johnson No. 1, a rotary combination derrick was erected. Rotary tools were used to 6,635 feet, just above the sand, and standard cable tools from there on. Drilling was started with rotary tools May 7th, 1931, and standard tools were rigged up from August 8th to August 15th and the well drilled into the sand August 24th, 1931.

The Reiter-Foster well was completed in a little over 100 days after drilling was commenced, but of this time 53 days were spent in cementing and in drilling out the cement left in the hole. Much better drilling time is now made in this field, because much of the trouble such as found in cementing casing in this well, has been overcome. Formations encountered in drilling in this field consist of sandy soil, sand, shale and hard lime to where the surface string was set. Below this point the principal strata are lime, shale, sand, sandy shale, shale and shells.

The casing program followed in the Reiter-Foster well was to set 122 feet of 15½-inch, 70-pound, 8-thread, pipe as the surface string. This was set on May 9th, 1931, and cemented with 200 sacks of

The Ida Johnson No. 1 flowing as it was drilled in.

Platte Valley Patterson No. 1 in foreground and Ida Johnson No. 1 in background. Note topography of country.

Stock tanks and separator at the Ida Johnson.

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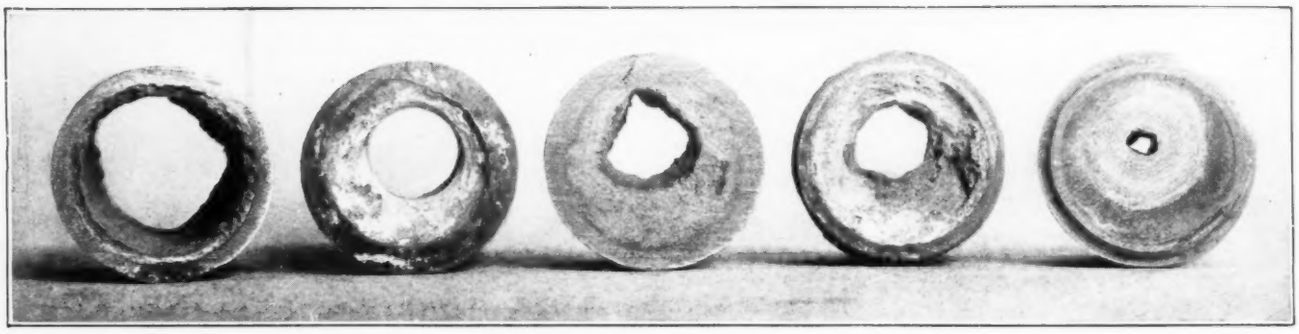

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quick cement. Drilling was resumed on May 12th. As this well was the pioneer rotary test it was originally planned to set and cement the next casing, 9⅝-inch O. D., 43½-pound, 8-thread, in the Timpas lime found in the lower part of the Niobrara and to standardize at this point. This string was set and cemented with 2,000 sacks of cement at 6,226 feet on July 6th, but resulted in the cement trouble here narrated. After drilling out the cement rotary tools carried the hole to a depth of 6,635 feet, where the seven-inch pipe was set with 750 sacks of cement, some of which set in the lower 1,600 feet of pipe. Standard tools were used in drilling this cement out of the hole, which job consumed eight days time. The day following the drilling out of the cement the well was drilled into the producing horizon.

Casing programs in later wells have varied slightly from that used on the Ida Johnson. It now is general practice to set the 9⅝-inch pipe at shallower depths. This string of pipe was set in the Continental Oil Company's Briggs No. 1, Section 13-6-61w, offsetting the Ida Johnson, at 5,550 feet and set with 750 sacks cement. The rotary hole was carried to the top of the sand, where the seven-inch was set with 750 sacks cement.

Drilling equipment on the Reiter-Foster well was very similar to that used in the Greater Seminole field of Oklahoma. The derrick was a 123-foot all steel one. A 12 x 12 inch twin steam drilling engine and a 4-speed, 3-shaft, draw-works was used. The rotary table was a 25½-inch, roller bearing type. Two 14 x 7½ x 18 duplex steam slush pumps circulated the drilling mud, the weight of which varied from thin at the top of the hole to about 10 pounds per gallon at the bottom. Steam for drilling operations was generated in five 90-horsepower boilers.

On this well 6⅝-inch O. D., 26-pound, and 4½-inch O. D., 11-pound drill pipe were used. Although rock bits were used principally on the Ida Johnson well, drag bits, red-heads and keystones have been successfully used on other wells. The control gate on the Ida Johnson was a 7-inch O. D. valve of 6,000 pounds test pressure, or 3,000 pounds working pressure.

The oil produced is a sweet paraffin base crude and contains very little sulphur. Following is an analysis of a sample from Patterson No. 1:

Gravity A. P. I.	40.8%
Color (10% solution ¼-inch cell Lovi)	55%
B. S. and W.	20%
Sulphur	.84%

SUMMARY OF YIELDS	% Crude
Gasoline (55.7 gr. 405 EP)	30.87
Kerosene (41.1 gr. 520 EP)	13.13
Gas Oil (35 gr.)	12.10
Wax Distillate (31.5 gr. 84 vis. @ 100F.)	26.90
Steam Refined Stock (560 flash, 167 vis. @ 210 F.)	15.60
Loss, fire and steam distillation, crude	1.25
Loss distillation heavy naphtha	.15
	100.00%

The producing sand of the Platte Valley and Reiter-Foster wells is the same sand as produces oil in the Wellington-Fort Collins fields along the mountain front to the west. In the latter fields, however, the wells showed much more gas, some producing as much as 80,000,000 cubic feet daily. The production in the Wellington-Fort Collins pools is solely from the upper or Muddy member of the Dakota

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We desire at this time to express our appreciation for the co-operation and assistance rendered Mr. E. B. Reeser during his three terms as President of the American Petroleum Institute.

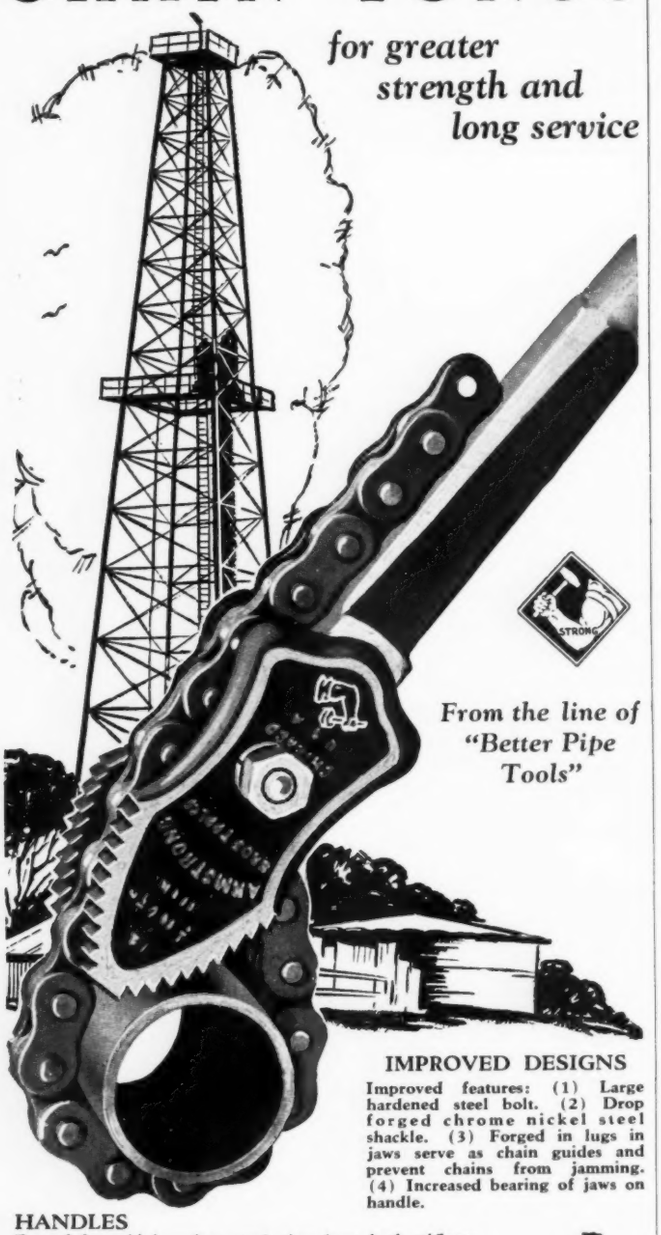
Barnsdall will continue to use its every effort toward working out a constructive program of improving the great Petroleum Industry, which we are confident is entering a period of permanent prosperity.

BARNSDALL

The *World's First* Refiner

ARMSTRONG BROS.
CHAIN TONGS

for greater strength and long service



From the line of "Better Pipe Tools"

IMPROVED DESIGNS

Improved features: (1) Large hardened steel bolt. (2) Drop forged chrome nickel steel shackle. (3) Forged in lugs in jaws serve as chain guides and prevent chains from jamming. (4) Increased bearing of jaws on handle.

HANDLES

Forged from high carbon steel, they have both stiffness and "spring"—they stand up under the hardest usage.

JAWS

Hold their sharpness, for they are drop forged from special steel; are heat treated, hardened and tested for lasting qualities.

CHAINS

Flat link chains are *proof-tested* to ⅔ catalog strength (1,200 to 40.000 pounds). You can rely on this *proven* strength.

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Armstrong Bros. Tool Co.

"The Tool Holder People"

331 N. Francisco Ave. - - CHICAGO, U. S. A.

Mid-Continent Representative:

EARL WADDELL

Fair Bldg. - - - - FORT WORTH, TEXAS

group. The lower and deeper sands are not productive in these fields. Elsewhere in the Rocky Mountain district oil is produced from different sands in the Dakota group with yields of from 5,000 to as much as 20,000 barrels to the acre in one instance.

At Fort Collins and along the mountain front the Dakota group is 350 to 400 feet thick with the upper sand averaging about 45 to 50 feet in thickness. A number of sands may be expected within the next 350 feet below the present depth of these wells. The present producing sand may run from 25 to 30 feet to as much as 60 feet in thickness.

Below the Dakota group is the Morrison and Sundance averaging about 400 feet in thickness, mostly Morrison. Permo-Triassic Red Beds may be expected from 7,400 to 7,500 feet. Good marine Pennsylvania beds were encountered in the Phillips Petroleum Company well, south of Wray, Section 3, T-2-S, R-42-W, 1,880 feet below the top of the Dakota. This interval would put the Pennsylvania in the Platte Valley area at about 8,500 feet. It may be, however, somewhat less, as the interval between the top of the Dakota and the Pennsylvania along the mountain front is somewhat less than in the Phillips well, the Platte Valley region is about half way between these two localities.

The Platte Valley or Greasewood Dome pool was discovered on October 10th, 1930, when oil was unexpectedly encountered in the Platte Valley Oil Company's Patterson No. 1. The well started flowing by heads every four hours from a sand at 6,640 feet (corrected measurement). Some gas accompanied the oil, and in October, gauged about 800,000 cubic feet daily. At the time oil was discovered there was 40 feet of open hole below the 4¾-inch casing and this pipe was not disturbed. From October 10th to November 30th the well produced 4,639 barrels oil, an average of about 93 barrels per day. On December 4th, 1930, it was drilled 16 inches deeper and increased its flow to from 130 to 150 barrels daily. Three days later it was again deepened, this time 14 inches, and production jumped to 350 barrels.

Production remained practically steady until August 29th when the Reiter-Foster Ida Johnson, located 1,000 feet north, was drilled in, when it showed a sharp drop. The Ida Johnson produced 1,720 barrels of oil and approximately 4,000,000 cubic feet of gas the first 26 hours. The top of the sand was found at 6,640 feet with a show of oil but the main oil was obtained at 6,644 feet, below a two-foot shale break. This well has now been deepened to 6,652 feet. Shortly after it was brought in its output fell off to 500 barrels daily. During the early part of September 2½-inch tubing was run almost to bottom but the well refused to kick off. The tubing was then raised 450 feet and swabbing started the well flowing 554 barrels oil daily.

The Platte Valley field lies in gently rolling country some ten miles north of the Platte River. The town of Orchard on the Union Pacific Railroad is the closest shipping point and lies about 9½ miles south and 2½ miles east of the Platte Valley well. Fort Morgan to the southeast and Greeley to the west are vying for first place as headquarters for the new field with the odds apparently a little in favor of Greeley.

Acreage in the pool is held by the Platte Valley Oil Company, Reiter-Foster-Platte Valley, Ohio Oil Company, The Midwest Oil Company, Continental Oil Company, The Prairie Oil & Gas Company, The Texas Company, Ramsey Petroleum Corporation and others.

Mrs. W. C. Campbell Dies at Eastland

MRS. W. C. CAMPBELL, 60, died October 15 at the family home on Halbryan street, Eastland, Texas, following a lingering illness of two years' duration. Funeral services were conducted from the First Methodist Church of Eastland by Dr. George W. Shearer, pastor.

Mr. and Mrs. Campbell came to Eastland from Wichita Falls. Mr. Campbell is division superintendent of the Prairie Pipe Line Company. The couple has one son, V. C. Campbell, of Walters, Okla.

S. R. Dresser Forms Canadian Company

THE S. R. Dresser Manufacturing Company, Bradford, Pa., announces the formation of Dresser Manufacturing Company, Limited, a Canadian corporation with main offices at 32 Front Street West, Toronto, Canada.

D. B. McWilliams is associated with the new company as director in charge of sales.

Petroleum Products Research Committee

THE Petroleum Products Research Committee of the Chamber of Commerce of Tulsa is interested in expanding the uses of petroleum and its products. It recently sponsored the Road Oil Congress, which was held in Tulsa, October 8-9. The purpose of the conference was to bring before the county commissioners and engineers, and petroleum refiners the possibilities of road oil, since this should furnish a large field for the sale of petroleum products. It was especially stressed that correct information on the use and application of road oils should be obtained, from which standard specifications could be formulated. J. B. Benson of the Barnsdall Oil Company is chairman of the committee.

Oil Equipment and Engineering Exposition

THE Oil Equipment and Engineering Exposition of Los Angeles, Calif., has been incorporated under the name of International Industrial Expositions, Limited, with E. G. Lenzner as president and general manager. There will be no change in the management and the permanent and annual oil expositions will be conducted under the original name.

Preparations for the Third Annual Oil Equipment and Engineering Exposition, which will be held in Los Angeles from February 1 to 7, 1932, are already well under way with several new features scheduled to add value to the show. Two derricks are in place on the grounds at 131st and Alameda Boulevard and are a part of the Permanent Exposition as well as the Annual. Besides the many displays of tools being shown, power-driven machinery is operated daily for the benefit of visitors from all parts of the world.

Petroleum Electric Opens Oklahoma City Office

THE Petroleum Electric Company has opened offices in Oklahoma City. The new offices are located at 531 W. Main Street and are in charge of A. D. Derby, sales engineer. Headquarters for the company are in Tulsa.

HERE IS THE END

to your

SCREENING PROBLEMS

THE LAYNE

Milled Groove Screen

This is the Layne Milled Groove Keystone Wire Wrapped Screen.

Observe the maximum inlet area provided by the oblong milled grooves leading to each hole drilled in the pipe. Notice how short a distance the oil flows before entering the screen, and also that each hole is fed by 10 or 12 V-shaped passages between the Keystone wires.

The entire outer surface of the screen distributes the fluid uniformly to all holes. This prevents sand cutting by eliminating excessive velocity at any one point. The short drainage distance between Keystone wires and groove prevents any possibility of clogging by mud or sand.

These grooves do not weaken the screen body, either for tensile or collapsible strength. Severe laboratory tests have proven it capable of standing 8,000 feet of drill pipe.

Put an end to your screening problems by installing the Layne Milled Groove Screen.

The Layne & Bowler Co.

HOUSTON, TEXAS

The Layne New York Co. 30 Church St., New York
The Layne & Bowler Corp. Los Angeles, Calif.
Vickers Limited, London, England

Strange but True...

HAPPENINGS IN THE PETROLEUM INDUSTRY

A gasoline line in California with a drop of 2,000 feet in it was opened at the upper end, and gasoline shot out into the face of a workman. There was a sag in the line below that point, and California sunshine did the rest.

B.H. Leonard
Rowayton, Conn.

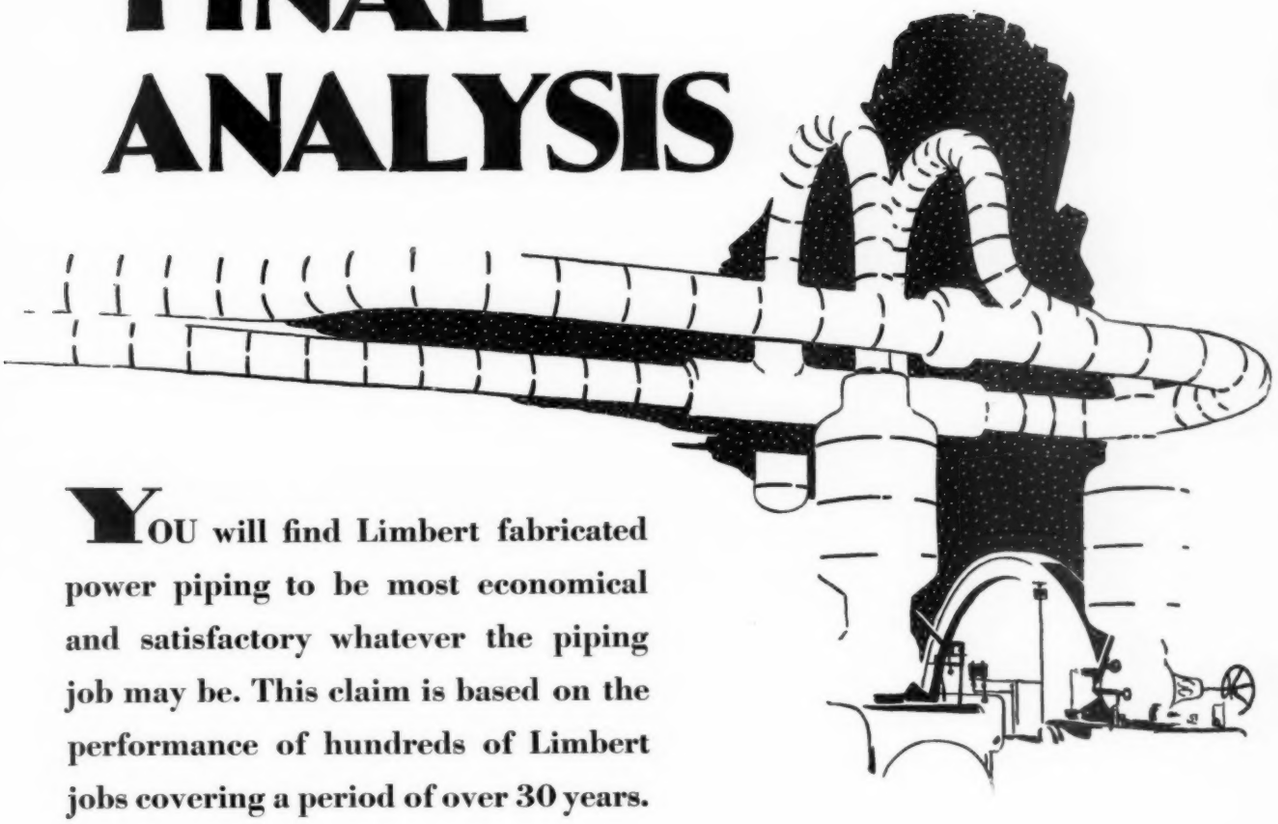
A calf nibbling grass received a broken neck when it got its head entangled in a pumping jack near Bartlesville, Okla., the well belonging to the National Oil and Development Co. The company is now being sued by the calf owner for maintaining an attractive nuisance.

When a string of tubing parted in a West Virginia well, leaving three joints of tubing, the anchor and working barrel in the hole, they were recovered when another string of tubing was being run in the hole. The anchor on the new string ran into the top of the lost tubing and became so tightly fastened that the lost joints were pulled to the surface.

C.W. Salisbury
Elk View, W. Va.

A drilling superintendent in Kirkuk, Iraq, wrote the following experience to Patterson-Ballagh Corp., Ltd.: A drill pipe slip was dropped in the hole and fell to the bottom alongside the drill stem. The driller immediately pulled out very carefully and upon extracting the drill collar (which was Bettis Stabilizer equipped), found that the slip had lodged on top of the stabilizer and was successfully brought to the surface in that manner.

IN THE FINAL ANALYSIS



YOU will find Limbert fabricated power piping to be most economical and satisfactory whatever the piping job may be. This claim is based on the performance of hundreds of Limbert jobs covering a period of over 30 years.

During this time there has never been a failure. The greatest of care is taken to insure proper fabrication not only regarding design, strength and durability, but also ease and economy of installation and maintenance.

Our engineers will gladly cooperate with your engineering department in the planning of complete piping systems and the selection of proper fittings. Our accomplishments are our best recommendations.

Geo. B. LIMBERT PIPING & Co.

GEO. B. LIMBERT & CO., 570 Fulton St., Chicago, Ill.

ST. LOUIS, MO. KANSAS CITY, MO. DETROIT, MICH. *Works:* EAST CHICAGO, IND.

An **"AMERICAN"**
with Gas Engine

Pictured is an "American" No. 4-A Fig. 1822 oil well pumping unit connected to a gasoline engine.

"American" units have been particularly designed to meet the various drive requirements of different localities.

"American" units are adaptable for pulley, V-belt or direct drive by gasoline engine or electric motor.

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THE AMERICAN WELL WORKS
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Donald R. Baker

The Use

THE kick-off pressure of a gas lift well depends entirely upon the submergence. Since the maximum output pressure of a compressor is limited, the tubing depth is often determined by the conditions of the surface equipment rather than by the conditions within the well. The use of kick-off collars, which are becoming quite common, gives the operator more control over the initial or kick-off pressure; and often makes it possible to increase the production of a well by lowering the tubing to a more desirable depth.

There are a number of these devices on the market. Some are designed to work when flowing either through the tubing or through the annular space between the tubing and casing. Others are designed to operate when flowing only one way. Obviously, one that will operate both ways is preferable.

All the collars operate on the same general principle. The collar contains one or more ports each equipped with a valve that is held open by a spring. Gas will pass through the port until the velocity reaches a point where the downstream pressure is so reduced that the valve closes. Static pressure then keeps the valve closed. The valves are designed so that a certain pressure differential causes the required velocity to close the valve while another pressure differential, which is usually smaller, keeps the valve closed.

The following example explains the operation of the collars:

Well depth, 5,000 feet.
Tubing, 5,000 feet, or just off bottom.
7" casing.
2½" tubing.
Fluid level 1,250 feet from top.
Fourteen collars spaced 250 feet apart, the first collar at 1,500 feet and the last at 4,750 feet.
Area of annular space 24.4 sq. in.
Inside area of tubing 4.67 sq. in.

Flowing Down Casing and Up Through Tubing

The first collar is located 250 feet below the fluid level, so when the pressure is applied to the annular space, the fluid level around the tubing lowers to 1,500 feet from the top. This causes the fluid in the tubing to rise, and its height above the collar will be:

$$250 + \frac{250 \times 24.4}{4.67} = 1{,}559 \text{ feet}$$

Assuming it requires a pressure of 35 pounds to sustain a column of oil 100 feet high, the pressure required to flow the oil in the tubing above the collar will be

$$\frac{1559 \times .35}{100} = 545 \text{ pounds}$$

When the oil in the tubing above the collar has been lifted by the gas, the resistance to the flow of the gas will be removed and the velocity through the collar will increase until the valve closes.

The fluid around the tubing will then be lowered to the next collar, and the process will be repeated until the well is flowing from bottom. The kick-off pressure of each succeeding collar will be higher than the one above since

of Kick-Off Collars

By DONALD R. BAKER,
Petroleum Engineer, Oklahoma City, Oklahoma

the working pressure increases with depth, but the final kick-off pressure will be only slightly higher than the final working pressure of the well. Thus there is a separate and distinct kick-off corresponding to each submerged collar in the well.

These calculations can be made by the following formula:

Let A_1 equal the area of the inlet.

Let A_2 equal the area of the outlet, or flow area.

Let S equal the distance between collars.

Let W equal the pressure required to sustain a column of fluid one foot high.

Let P equal the pressure required to flow the fluid above the collar.

The formula, then, is:

$$\left\{\frac{A_1}{A_2} + 1\right\} SW = P$$

Applying the formula to the above case, the solution is:

$$\left\{\frac{24.4}{4.67} + 1\right\} \times 250 \times .35 = P$$

$$6.23 \times 250 \times .35 = P$$

$$P = 545 \text{ pounds}$$

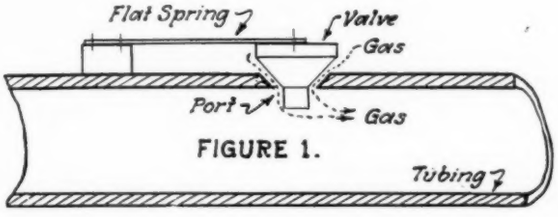

FIGURE 1.

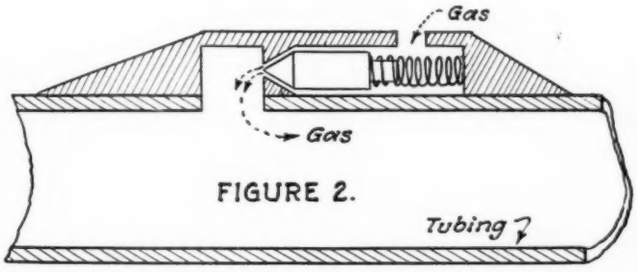

FIGURE 2.

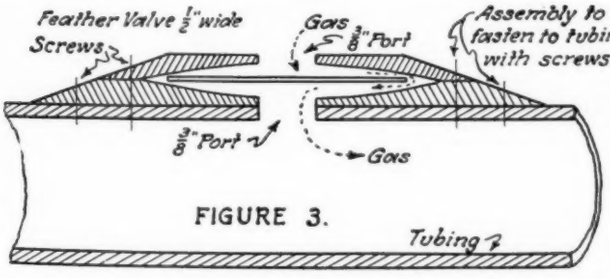

FIGURE 3.

Figure 1. A popular type of kick-off valve in use. It is also available with double seats to flow inside or outside the tubing.

Figure 2. Another type of kick-off valve.

Figure 3. Here is an adaptation of the Worthington Feather valve to kick-off collar.

BAROID

EXTRA-HEAVY COLLOIDAL DRILLING MUD

BAROID is a uniform, high-grade specially prepared pulverized weight material for increasing the weight of Drilling Mud to overcome high gas and water pressures.

BAROID has a specific gravity of 4.2 and is compounded so as to enable the preparation of pumpable Muds weighing 140 to 150 lbs. per cubic foot.

Drilling Muds made up from BAROID will not settle out if circulation is suspended and are free from dangers of stuck drill pipe or casing.

Strict laboratory control assures highest quality in manufacturing and co-operation by our experienced field men provides exceptional service for BAROID users. Literature on request.

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TROUBLE-PROOF COLLOIDAL DRILLING MUD

AQUAGEL is a uniform, specially treated high-grade clay packed in 100-lb. sacks and carried in all oil fields. One ton of AQUAGEL makes 180 bbls. of Drilling Mud when mixed in the proportion of 3% by weight in water.

AQUAGEL provides the cheapest source of gel-forming colloids which prevent caving, stuck drill pipe and casing, and loss of circulation. Ask for literature.

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MARTIN-DECKER *AUTOMATIC* MUD SCALE

A new and improved trouble-proof device—easily installed—for continuously indicating and recording on a chart, the true weight of your mud. An important safeguard against danger from blowouts. Ask for literature.

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IT HAS TO BE PLIABLE

No gentle treatment here! We are testing the toughness of the steel wire used for Yellow Strand Rotary Drilling Lines. Not just *bends*—but *reverse* bends, through an arc of 180°. It must withstand a required number of bends before breaking, and a number of other severe tests, to be used at all.

You need a line of *proved* toughness and pliability for those multiple sheaves. You get these in Yellow Strand, the super line, together with resilience and strength, which spell stamina. No internal stresses in our Flex-Set Preformed Yellow Strand. Try it.

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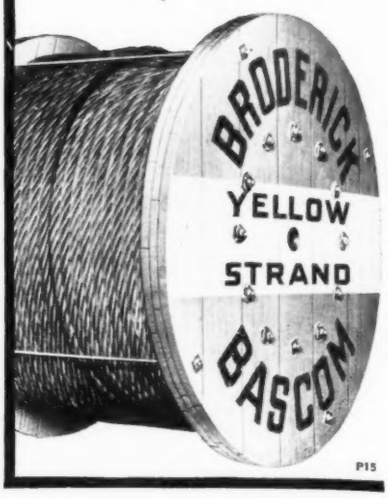
We also manufacture Patentsteel, Extra Strong Cast Steel and Cast Steel Cable Tool Drilling Lines, Sand Lines and Pumping Lines.



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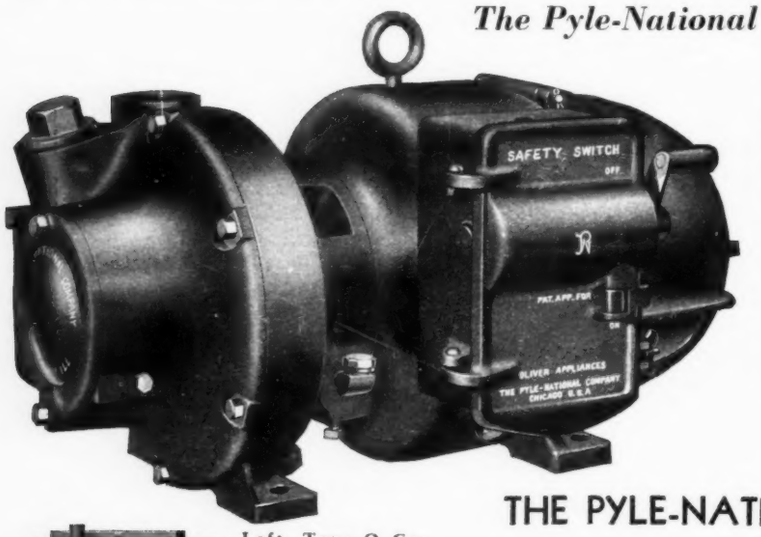
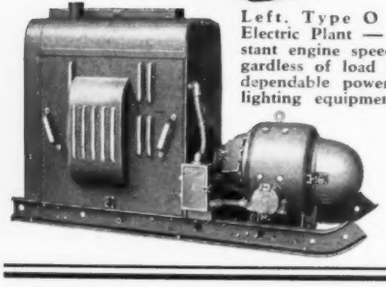
DEPENDABLE LIGHTING

The Pyle-National Type M-2-S Rig Lighting Unit



The Pyle-National Type M-2-S rig lighting unit, because of skillful design and careful methods of construction delivers steady, reliable lighting service month after month. Extra large bearings, plenty of field copper, a compact rugged governor unit, and the finest materials throughout, are some of the features that make this a real "Heavy Duty" machine. Safety switch and fuse box is standard equipment, making type "M-2-S" a complete unit, easily installed and operated.

Send for Bulletins With Complete Description



Left. Type O Gas Electric Plant — constant engine speed regardless of load gives dependable power for lighting equipment.

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General Offices and Works:
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Direct Factory Representative, R. F. Kilker,
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Left. This Vaporproof fixture takes Standard RLM reflector. It is one of the many Pyle-National vaporproof fixtures giving safe lighting in the presence of fumes, gases and moisture.

Pyle- O -Lyte Floodlight Projectors — for efficient, evenly distributed yard illumination.

PE11Gray

Flowing Down Tubing and Up Through Annular Space

If the flow is reversed and the well is to be flowed through the annual space with the same kick-off pressure, the spacing of the collars can be calculated from the formula as follows:

$$\left\{\frac{4.67}{24.4}+1\right\}\times .35S = 545$$

$$S = \frac{545}{1.1514\times .35} = 1{,}302 \text{ feet}$$

The first collar will then be located 1,302 feet below the fluid level, or 2,552 feet below the top of the well. The second and last collar will be placed at 3,854 feet. Thus, instead of 14 collars being needed as in the first case, only two collars are required.

If it is desired to flow such a well through the tubing, it is advisable to connect the well so that it can be kicked off through the annular space, and the flow later reversed, thereby reducing the number of collars required from 14 to two.

Kick-off collars are also useful when it is arranged to flow several wells from one gas line. In this case it is often necessary to have two gas lines, a small high pressure line to use for kicking off a well, and a larger line to flow the wells. Otherwise, the pressure on the whole system must be raised to kick off a well. When another well in the system is already flowing, careful regulation is required to divert the excess pressure to the well that is being kicked off and not allow it to blow through the producing well. If kick-off collars are used on all wells in the system, only one gas line is required and less regulation is necessary as high kick-off pressures are not required.

The collars can also be used on wells flowing naturally through tubing. Such a well may not have sufficient rock pressure to kick itself off, but still have sufficient pressure to flow naturally after it is kicked off. Kick-off collars installed in the string of tubing will act as jets in starting the well to flowing, but will close after the flowing starts. They therefore have the advantage of jets in starting the flow, but they later close so do not have the disadvantage of jets in lowering the efficiency after the well is flowing.

International-Stacey to Distribute Wheeling Products

CONFIRMATION has been received from the International-Stacey Corporation, Columbus, Ohio, and from the Wheeling Steel Corporation, Wheeling, W. Va., that arrangements have been completed for world wide distribution of Wheeling oil country tubular goods to the oil and gas industry, through the sales organization of The International Derrick & Equipment Division of International-Stacey Corporation. This rounds out Ideco's very complete line of pumping and drilling material and comes as the result of negotiations during several months between officials of both companies. As rapidly as possible Ideco will establish stocks of Wheeling tubular goods, consisting of welded and seamless pipe throughout the active oil and gas fields at strategic distributing centers. This arrangement does not disturb the identities of the two companies, nor does it affect the existing distribution of Wheeling tubular goods through other channels.

The Wheeling line of welded and seamless oil country pipe includes A. P. I. and standard drill pipe, casing, tubing, line and drive pipe in a complete range of sizes and weights and thus enlarges the service of International-Stacey Corporation to the industry. For the refinery and pipe line companies, this arrangement immediately makes available Wheeling tubular goods in distributing centers close to their fields of activity.

Daily! Not After the Job is Done

Cost of *Crooked Drilling* and resulting increased pumping expenses *can be eliminated!*

• • • THE Syfo Clinograph records deviation from the vertical in drilling progress.

• • • DAILY use of the Syfo enables the driller to *control direction.*

• • • THE test records are made on recording paper for reference purposes.

• • • THE test is quickly and easily made *without the use of acids.*

SYFO Clinograph ("The Ink Bottle")

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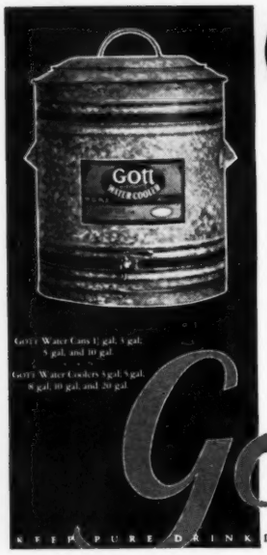

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When you have a GOTT Water Cooler handy, you will always be assured of a fresh supply of pure drinking water kept delightfully cool. *Order one from your supply store . . . now!*

GOTT Water Cans 1 gal., 3 gal., 5 gal. and 10 gal.
GOTT Water Coolers 5 gal., 5 gal., 8 gal., 10 gal. and 20 gal.

Gottkool

H. P. GOTT MFG. CO. • Winfield, Kansas

KEEP PURE DRINKING WATER ALWAYS HANDY

Keep Pure Water Always Handy

H. P. Gott Mfg. Company
WINFIELD, KANSAS

NEW!

Continuous Flow
VIGILANT
Liquid Level
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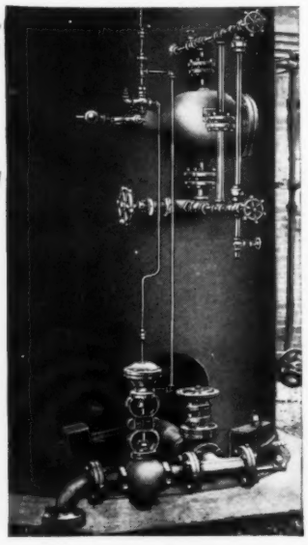

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Complete details gladly furnished.

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The CHAPLIN-FULTON MFG. COMPANY
28-40 Penn Ave. Pittsburgh, Pa.

Adaptability of Hard Surfacing Materials to Oil Field Diamond Drilling

By EDMUND B. STILES [1]

DUE to the excessive cost of Brazilian black diamonds, or carbon, as they are frequently called, many metallic substitutes have been introduced to users of diamond core drills. Some of these diamond substitutes gave satisfactory service under certain conditions.

Haystellite, a cast tungsten carbide, developed by the Haynes Stellite Company and having both toughness and hardness, was first brought to my attention some eighteen months past. It was being used on structure testing drills in the Northern Mid-Continent with satisfactory results. We were determined to get away from the necessarily large investment in carbon. Our superintendent in charge of the drills in the field was reluctant to "monkey with any more substitutes" but finally agreed to run it. After a week's trial in the Mexia-Powell fault line area (Texas), he was enthusiastic about the results obtained with Haystellite and we have run diamonds only on one or two occasions since.

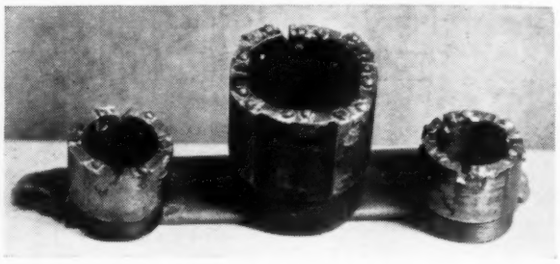

Fig. 1 (At Left)—"N" Bit (2-inch core) with No. "O" half round Haystellite slugs cast ends up. (Center) "K" Bit (3-inch core) showing both the cast ends and broken ends of No. "O" half round and No. "O" hexagonal Haystellite slugs. (At Right) "N" Bit with broken ends of hexagonal Haystellite slugs. Note "Kickers" or gauge stones in sides of bit.

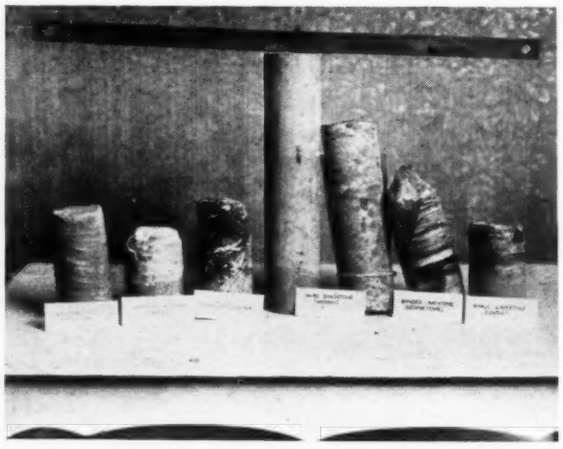

Fig. 2—"N"'s cores from various formations taken with Haystellited core drills. Note chert boulder (white portion) in second core from left.

A wide variety of materials have been drilled, ranging from hard sandy limestone of the Midway (Tertiary Eocene) to the massive limestone containing chert concretions of the Edwards (Commanchean Cretaceous). The Austin chalk (Gulf Series), the most resistant formation

[1]Geologist in charge of Diamond Drills, Texas Prod. Division, The Pure Oil Co.

encountered in drilling for production in the Woodbine sand producing area of Texas, is "easy pickin'" for bits set with this material.

Haystellite has the necessary hardness to withstand the abrasive action of sandstones and similar formations to a marked degree, and it also has sufficient toughness to withstand a decided impact such as is frequently encountered by the bit in drilling. This feature is of great advantage in oil field drilling practice as it enables the driller to carry more open hole than would be possible with diamonds. A few pieces of iron pyrites or chert pebbles loose in the hole will do little or no damage to a Haystellite bit.

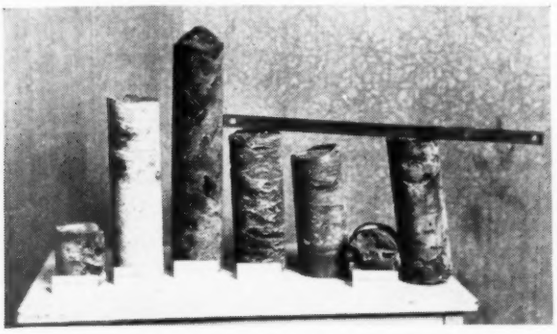

Fig. 3—"K" cores of Permian materials taken with Haystellited core drills.

It has been our experience that the best results are obtained with Haystellite when the slugs are hand set in the same manner as used with diamonds. We use a hexagonal slug 5/16x1¼ in. long for "N" size bits (2-in. core). The setter will break these slugs in half and set the broken end out for cutting in hard formation. For a softer formation, old slugs from a used bit will be turned upside down and the cast end used for cutting.

The blank bits are drilled in the machine shop, using a templet of tool steel to guide the drill so that holes may be cut partially outside the circumference of the bit for outside and inside clearance. The slug is shimmed with

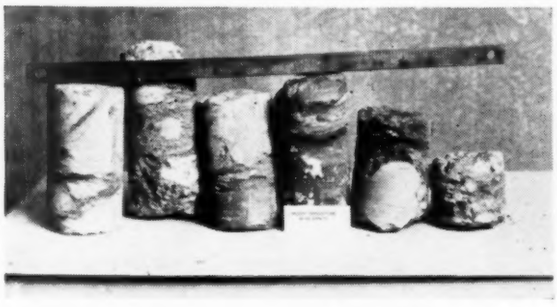

Fig. 4—"K" cores of Commanchean Cretaceous taken with Haystellited core drills. Note large lump of iron pyrite at top of muddy sandstone core.

copper wire, wire solder or horseshoe nails, just as a stone would be in diamond setting, and the bit metal peined around it.

Greater clearance may be used with the slugs than is practical with diamonds, but it is not advisable to use an excessive clearance. Too much clearance, especially on the bit face, tends to gouge and make a heavy drag on the drill. Also if it should be necessary to run diamonds in a very hard bed, the following bit would have to be set to the same gauge as the diamonds. For this and other reasons, it is

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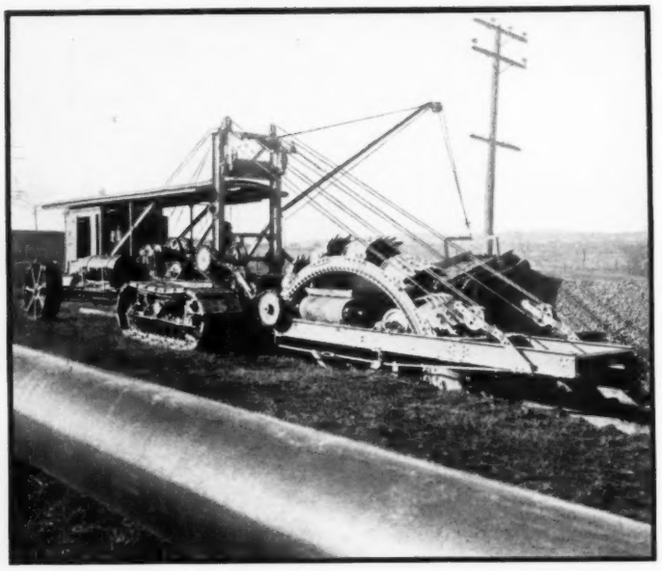

Right Through Hardpan and Limestone

One of the two Buckeye heavy-duty Model 48 Pipe Liners employed on this job is pictured in profitable action on a 24-inch natural gas line. Cutting through hardpan and some limestone, it is averaging 1,000 lineal feet of 36-inch wide by 8 feet deep ditch in 8 hours. On other jobs, where soil conditions were favorable, this model has excavated as much as 5,000 lineal feet of trench in one day.

Largest of Buckeye's complete line of Pipe Liners, Model 48 is expressly designed and constructed to deliver plenty of completed big trench at remarkably low cost. Its 6 cutting widths scale from 22 to 40 inches, inclusive, with a maximum digging depth of 8½ feet.

Built directly to the specifications of the industry's leading engineers and contractors, every Buckeye Pipe Liner—large or small, and within its respective service range—embodies the same dependable working ability. Over 30 years' successful experience has proved the soundness of the Buckeye operating principle and construction. More important, it has caused all Buckeyes to be recognized internationally as *the ditchers that best meet all oil, gas and pipe line requirements.*

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best that the bit be set on the job and for the conditions under which it is to be run.

Many users have their bits brazed in by a machinist or by the manufacturer. While I have used very few bits set in this way, I am opposed to the method for several reasons, some of which I will mention. Very few brazed bits will be found to be of smooth gauge, either inside or outside. It is difficult to properly place the slugs while brazing without obstructing the flow of metal around the slug and the result is either that the slug is not well seated in the bronze or that it is slightly out of gauge. A bit with one or more "high" stones will run "rough" and will develop a chattering or lashing effect on the machine. There is also a tendency for a poorly gauged bit to start a hole off from the vertical.

Brazing seems to develop small fractures and cracks in a Haystellite slug which frequently do not show up until the bit is put in use. A slug fractured in this way will chip and break very easily in normal drilling and often leave large pieces of the slug in the hole. The fracturing is apparently due to applying the torch too suddenly to a cold slug. Heating the slugs slowly to a red heat before brazing might overcome this difficulty.

As I mentioned above, each bit should be set for a specific task. Different formations require different tactics and change of formation is the most important factor to be considered in drilling operations. It is our practice to keep only one or two bits per rig set up ahead of the drillers and frequently these are laid aside and a bit set for a special job. This practice would be practically impossible with brazed bits as the operator cannot put the individuality into a brazed bit that can be put into a hand-set bit.

Original Cost

The cost ratio between tungsten carbide and black diamonds or carbon is roughly 1:30,000 based on current prices of both articles. A six-stone diamond bit "N" size will inventory slightly over $3,150.00. After six months' average use this investment will depreciate 40 per cent to 60 per cent and in eight months' use the investment may be marked off as total loss. Also one bad hole may wipe out the entire investment in five minutes and cost several hundred dollars additional trying to recover a stuck bit. On the other hand, $100.00 worth of Haystellite will run a drill a year and if you stick a bit you have have lost only about 60 cents worth of diamond substitutes.

Rate of Drilling

I have only observation to govern the estimates regarding comparative rates of drilling between diamonds and Haystellite. The rate of cutting is dependent entirely on the material encountered in drilling and while diamonds will cut somewhat faster in hard rock drilling, the Haystellite will equal or better the time in softer material such as shale and sands. A footage of 60 to 80 feet per 24 hours is about the average in mixed formations at an average depth of 800 feet where continuous core is being taken. This rate would not be materially increased by the use of diamonds due to the additional care necessary in going in and out of the hole and in cleaning the hole of loose gravel or pyrite. It is probable that under similar conditions, diamonds might drill 100 feet per month more than Haystellite, but they would probably not exceed this amount.

Conclusion

The use of Haystellite as a diamond substitute has materially reduced the cost of structural drilling both from the point of initial investment and operating cost. The fact that this material has been tried and is now in use in practically all the Mid-Continent and California areas where structural drilling is being done, speaks very highly for its qualifications.

International Acetylene Association Thirty-Second Annual Convention

THE most comprehensive discussion ever given of methods for testing oxy-acetylene welded joints will be one feature of the thirty-second annual convention of the International Acetylene Association at the Congress Hotel, Chicago, November 11, 12 and 13.

At the weld-test session, November 11 at 8:15 p. m., Prof. H. L. Whittemore of the United States Bureau of Standards will speak on the importance of tests to welders and to users and makers of welded products. There will be a dramatized demonstration of visual and stethoscopic tests; hammer, bending, tension and hardness tests; invisible-ray tests; specific gravity, compression, and internal pressure tests.

At this session, a weld-strength estimating contest will be held. Three welded specimens will be displayed, and everyone present will have a chance to estimate their average tensile strength. The five estimates closest to the figures revealed on a portable tensile testing machine will win valuable prizes.

Among the timely speeches at this session will be "Today's Opportunities for Welding-Trained Men in the Metal Working Trades and Industries," by Dr. S. Lewis Land, educational director of the Heating and Piping Contractors' National Association; and "Training Gas Welders for the Job," by Thomas Jones, superintendent of welding for the Illinois Steel Company.

The other sessions will cover every important field where oxy-acetylene welding is used, opening on November 11 at 2:00 p. m. with a talk by Rufus C. Dawes, president of "A Century of Progress."

Prof. Comfort A. Adams of Harvard, and G. O. Carter, consulting engineer, will discuss the welding situation in general.

The use of the oxy-acetylene process in transportation industries will be treated on November 12 at 10:00 a. m. Welding on the U. S. Airship Akron, scrapping railroad cars by the production line method with the oxy-acetylene blowpipe, and "Present Practices in Rail Bonding."

At 2:30, November 12, outstanding authorities on welded piping will discuss welded heating, water, and air-conditioning systems; overland oil and gas lines; and the use of special fittings for welded installations.

The Chemical Industry Session, November 13 at 10:00 a. m., will deal with high-pressure, high-temperature chemical piping; methods of welding the new corrosion-resisting alloys; and welded power piping. Charles Gorton, chairman of the Uniform Boiler Law Society, will explain the use of gas welding under the revised A. S. M. E. Boiler Code.

The two o'clock meeting will treat engineering education in welding, with W. H. Mager of the General Motors Institute of Technology, speaking on this topic. Prof. S. C. Hollister of Purdue University will discuss "What the Welding Industry Must Do to Receive Engineering Acceptance More Rapidly."

At this session the Oxy-Acetylene Committee Report describing the year's progress in the use of welding will be presented. Admission to any or all sessions of the convention is free, and anyone interested in hearing up-to-the-minute discussions on the above topics may obtain tickets at the convention headquarters in the Congress Hotel or from the International Acetylene Association, 30 East 42nd Street, New York.

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Use of Air Reduces Pumping

SEVERAL companies operating in the Mid-Continent oil region have been experimenting with an air chamber that is installed in the hole of a pumping well for the purpose of reducing the well load. After several months of experimentation in finding the proper capacity chamber for different depth wells the results in reducing the down-time trouble on wells particularly hard to pump have been remarkable, and increasing interest in the use of this piece of equipment has been aroused because of its success.

The Indian Territory Illuminating Oil Company was the first to commence experimental work along this line, with the Union Machine Company of Bartlesville, Okla., cooperating in making the air chamber. The first work of the Indian Territory company was started in January of this year, when an installation was made on its L. Bowlegs No. 2 well in the Seminole pool—a well that had given much trouble from sucker rod breakage.

The first chamber installed by B. O. Hindman, district superintendent, was 20 feet long. Tests showed that the chamber was not long enough to operate successfully in a 4,200-foot well, consequently in August of this year he placed a chamber 50 feet 5 inches long by 5 inches outside diameter, with a capacity of 4,700 cubic inches of air, 500 feet off bottom in the well. The well was equipped with 2½-inch tubing, ¾-inch sucker rods, and was being pumped at the rate of 24 strokes per minute from the fourth pitman hole, with a counterbalance having an effective weight of 4,500 pounds.

A feature of the results has been a decrease in the maximum load of from 1,250 to 2,500 pounds when using the air chamber. A dynamometer test prior to installing the chamber showed the results given below.

While the rate of production, which is about 450 barrels of fluid daily with 50 barrels of this amount oil, has remained practically the same, the well's production has been more constant and, as a result, over a period of time, its

Test No. 1

No.	S.P.M.	Average (Loads in thousand lbs.) Max.	Min.	Up	Down	Mean	Horsepower At Polish Rod	At Engine
1	20	14.75	4.0	12.65	7.1	9.87	52.7	16.75
2	21	14.8	3.8	12.95	7.0	9.97	57.8	17.75
3	23	15.25	3.8	13.03	5.7	9.36	58.8	23.2
4	25	15.6	4.2	13.52	6.48	10.00	68.2	23.7

One day after the 5-inch by 50-foot 5-inch chamber was installed a dynamometer test was made and gave the following results:

Test No. 2

No.	S.P.M.	Average (Loads in thousand lbs.) Max.	Min.	Up	Down	Mean	Horsepower At Polish Rod	At Engine
1	20	11.2	4.0	11.0	6.96	8.98	50.0	10.1
2	21	12.0	3.8	11.63	6.43	9.03	51.7	14.7
3	24	13.4	4.8	12.63	6.83	9.73	63.0	18.9
4	25	13.5	4.7	13.1	6.48	9.79	67.0	22.6

Three weeks later another test showed the following results:

Test No. 3

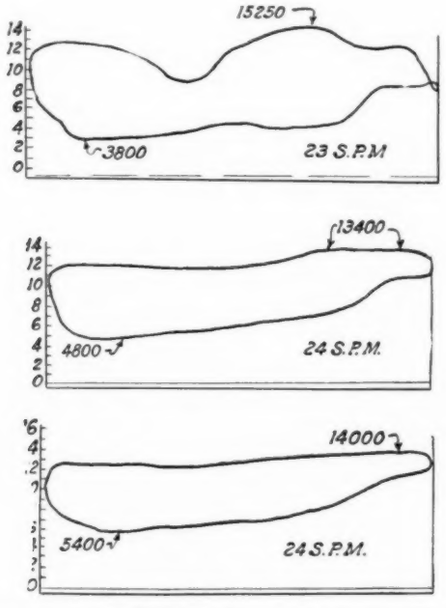
No.	S.P.M.	Average (Loads in thousand lbs.) Max.	Min.	Up	Down	Mean	Horsepower At Polish Rod	At Engine
1	20	13.3	4.25	11.50	6.95	9.15	50.0	11.9
2	22	12.9	3.9	11.48	6.81	9.14	54.9	14.02
3	24	14.0	5.4	13.16	7.73	10.44	68.3	17.3
4	26	13.1	3.8	12.5	5.62	9.05	65.0	23.8

Chamber
Wells' Down Time

recovery has been larger. The output of the well on Test No. 1 was 64 barrels of oil and 360 barrels of water; Test No. 2, 50 barrels of oil, 317 barrels of water; and Test No. 3, 50 barrels of oil and 317 barrels of water.

It is interesting to observe that, in addition to decreasing the maximum loads, the tests show that the use of the chamber has resulted in a decreased horsepower delivered from the engine and at the polish rod of approximately 25 per cent. The dynamometer cards also show that when using the chamber the loads are more even, having less irregularities, and that there is longer rod life.

The outside casing of the air chamber is made from seamless pipe. The well tubing passes through the chamber with the exception of a small opening in the bottom. The chamber traps a quantity of the fluid and, being packed off at the top, it is compressed by the pump movement so that a cushion effect is obtained.



Dynamometer tests on L. Bowlegs No. 2 well, from top to bottom: Test made prior to installation of air chamber; first day after installation; and another test made three weeks after it was installed.

Since the success of the Indian Territory Illuminating Oil Company in operating its wells with the chamber, the Union Machine Company has installed the equipment on very troublesome wells in widely scattered areas of the Mid-Continent. In all instances the installations have been successful. The Phillips Petroleum Company placed one of the chambers on a well that had been having 25 to 30 sucker rod breaks a month. The well operated eight days before the first break and its subsequent operation has been even better than this. In a great many cases there has been such a reduction in down time that wells have pumped 100 to 200 days without a shutdown.

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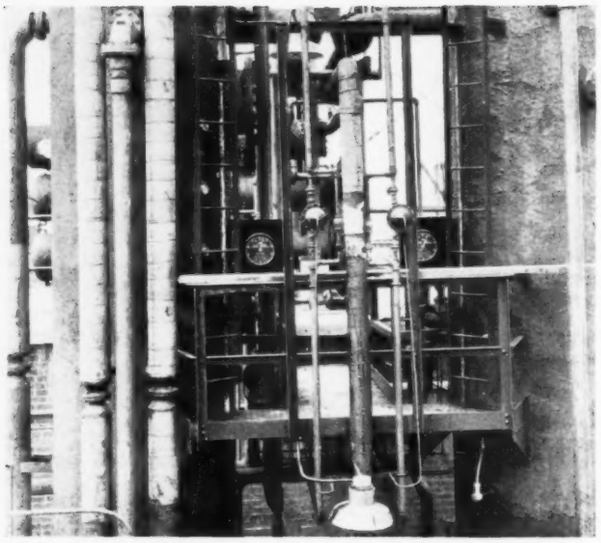
Air-Operated Control Methods

By W. C. BEGEEBING*



Tag temperature controllers of non-indicating type of towers of Arthur G. McKee unit.

EVER since automatic control was first used in industry, the air-operated device has been favored because of its reliability, flexibility and power. Its reliability is evidenced by its use as motive power in other fields—as, for example, air brakes. Even slight leakage in an air-operated control system does not interfere with its functioning, as the volume is usually sufficient to make up for the leakage, which in itself is not objectionable, as would be the case with steam or hydraulic.

An air-operated control system consists of the following elements: (1) A dependable source of reasonably clean and dry compressed air at a uniform pressure, (2) the controller itself with its tubing and sensitive bulb, (3) the diaphragm valve, which does the actual regulating of the heating or cooling medium, (4) suitable air piping connecting controller to valve.

The diaphragm valve is so important a factor in successful control that, while it is illustrated and mentioned frequently in this chapter, it merits a complete chapter in itself, which will appear later.

Just how the uniform air supply is employed to operate the diaphragm valve may now be considered. Several methods are employed and all of them follow the same general lines. The movement of the pressure spring, as the temperature changes, either operates directly on a small pilot valve or is multiplied by a lever. In one make the pilot ball valve is virtually a three-way valve which in one extreme position shuts the supply and vents the controlled air line and diaphragm top of the valve, thus opening the valve wide; and in the other extreme position closes the vent and allows the full air supply to act on the diaphragm top, thus closing the valve tight; and in intermediate positions, by allowing some of the air supply to leak past the pilot valve pin, causes the diaphragm to throttle or occupy a partially opened position. In other makes the pilot valve is a two-way valve and an air leak is placed between the controller and the diaphragm top of the valve. The pilot valve when fully opened closes the diaphragm valve; when fully closed the supply is cut off and the diaphragm top vents through the air leak, thus opening the valve; when partly opened the valve is held in an intermediate position. Either of these two methods are typical of the non-indicating pressure spring instruments and the expansion-stem types.

A somewhat different system is used in the indicating and recording pressure spring controllers. In these the movement of the pointer or pen arm operates a flapper which opens, closes or throttles a small orifice valve connected to the air supply through an orifice smaller than the controlled orifice. Between these two orifices is connected a diaphragm or capsular spring. Now, with the orifice valve closed by the flapper, the capsular spring will be expanded by the full air supply pressure, and with the orifice valve opened the air will vent through it faster than it can be supplied through the smaller orifice, so that the capsular spring will be deflated. Partial closing of the flapper orifice valve will, of course, give partial expansion of the capsular spring. The capsular spring acts as a relay to operate a pilot valve (similar to those already described) by which the diaphragm valve is functioned. By means of this "double relay" arrangement only a very small amount of power is needed and consequently the pen arm or indicating pointer is not restricted in its movement. Thus, very sensitive and accurate control can be obtained. A further advantage of this type lies in its adjustability from the standpoint of modifying the diaphragm valve movement in relation to the amount of deviation from the setting point. This is accomplished in one make by shifting the orifice nearer to or further from the flapper fulcrum. When nearer the fulcrum the full diaphragm valve movement is spread out over a greater change in temperature and better throttling action obtained by reducing the chance for open and shut valve operation. In another make this adjustment is accomplished by adjusting the angle (to the orifice face) of an auxiliary flapper.

In controlling top tower temperatures or on other apparatus where open and shut valve operation is objectionable, a sensitive air-operated controller might keep the controlled air swinging back and forth between 0 and 15 pounds. To correct this open and shut regulation the following arrangement is sometimes adopted. Somewhere in the controlled air line, usually just where it is connected into the pilot valve, a metal plate with a very fine orifice is located. In addition a reservoir, termed a volume or capacity vessel, in the shape of a five-gallon or larger tank, is placed in the controlled air line. In this way, even though a small temperature rise or fall above the setting point will cause the air valve to open or shut wide, the change in air pressure on the diaphragm top of the controlled valves takes place very slowly. Thus, floating or throttling valve action is encouraged. This expedient has, however, a very serious limitation. If the temperature rose or fell considerably the diaphragm valve would not respond soon enough and might allow the deviation to become very great. Such fixed-time lagging of diaphragm response can only be dependable if the rapidity of the temperature changes is uniform and if the changes are small in amount. The orifice valve adjustments for the same purpose do not carry these penalties and should be preferred.

Recent developments have been made to insure balanced control action in air-operated control which render the above expedients unnecessary. By means of these balancing

* C. J. Tagliabue Manufacturing Co.

arrangements, which are built into the instruments, "hunting" and overcontrol tendencies are eliminated and complete regulation by the diaphragm valve (without manual adjustment of the by-pass) is achieved, even under wide variations of process conditions.

Air-operated temperature controller may be made to open the diaphragm valve with a rise in temperature above the setting point (as in tower control or any other cooling regulation), or to close the valve (as in steam still control or any heating control). The pilot valve in the controller may be reverse-acting or direct-acting or a direct or reverse-acting diaphragm valve may be used. Since there is some confusion (not to say contradiction) in the nomenclature used by various manufacturers, the safest plan in specifying is to state whether the valve is to open or close with a rising temperature. The various combinations of controller and valve follow.

Since air failure must sometimes be reckoned with from the standpoint of safety, this tabulation also shows whether the valve spring will close or open the valve when air fails.

HEATING PROCESS (OR PRESSURE REDUCTION)

Controller	Diaphragm Valve	When Temperature (or Pressure) RISES	FALLS
Direct	Direct	Air closes valve	Spring opens valve
Reverse	Reverse	Spring closes valve	Air opens valve
Reverse	Reverse top	Spring closes valve	Air opens valve

COOLING PROCESS (OR EXCESS PRESSURE RELIEF)

Controller	Diaphragm Valve	When Temperature (or Pressure) RISES	FALLS
Reverse	Direct	Spring opens valve	Air closes valve
Direct	Reverse	Air opens valve	Spring closes valve
Direct	Reverse top	Air opens valve	Spring closes valve

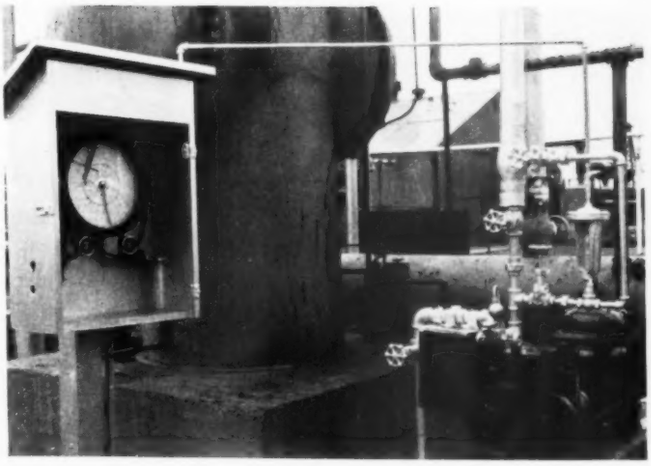
It has already been mentioned that clean, dry, compressed air at a uniform pressure is required. No single step toward reducing trouble and maintenance expense will be more greatly rewarded than provision to insure the cleanest, dryest and most uniform source. Most air-operated controllers include a small air filter, but these filters cannot for long purify an extremely bad air supply. A group of controllers will easily justify the installation of an adequately large air purification arrangement. It is especially desirable to include a trap which continually removes condensation. A filter alone, even if it were 100 per cent efficient, would be 100 per cent useless if it were not manually blown out at frequent enough intervals. How frequently? Why wonder, when a trap will never forget? Moisture and oil vapor in air is objectionable, not only because of fouled instruments but because of possible freezing of moisture in cold weather. Air compressed indoors in winter and used outdoors is especially vulnerable. A simple plant-made condenser will avoid this trouble.

The air piping between air supply and controller and thence to valve should be ⅛-inch brass pipe, although the use of iron pipe is condoned if it be galvanized. Copper tubing instead of brass pipe is being more and more used because of the ease with which it can be strung and the fact that fewer joints are needed, consequently less places to look for leaks when any are suspected. Application of soap solution is the readiest detector for air piping leakage.

When a number of controllers are supplied by the same line it must be large enough so that the air demands of any controller do not curtail the supply to the others and thus affect their operation. The following relation may be used with confidence.

⅛" for not more than 4 controllers
¼" for not more than 8 controllers
⅜" for not more than 18 controllers
½" for not more than 27 controllers

Connect off-takes to controllers from main air header from the top of the header, which should preferably be horizontal, pitched to a blow-out valve. If a vertical main air supply header is used, provide a blow-out valve (or a trap) at its base to remove condensation accumulations.



Recorder-controller maintaining uniform kettle temperature on a stabilizer.

Yard air is sometimes used for controllers, with or without a small compressor "standing by" in case of its failure. Sometimes the compressor is arranged to go into service automatically when the yard supply is shut down during the night.

Each controller manufacturer offers an inexpensive, self-operating air reducing valve to bring the air pressure to the uniform 15 pounds required. For a considerable reduction it is advisable to use two of these in series. Thus, to reduce 100 pounds to 15 pounds, good practice is to have the first stage from 100 to 45 pounds and the second stage from 45 to 15.

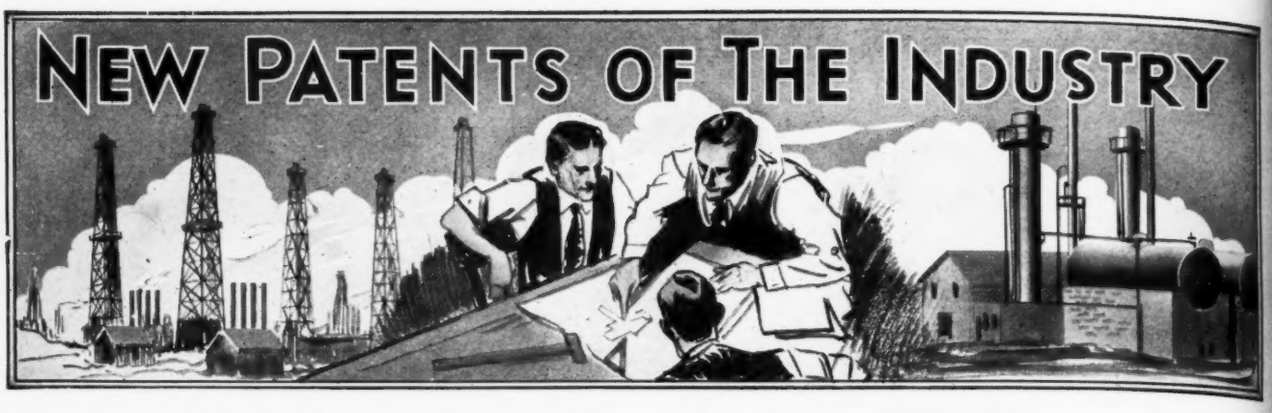
Where clean, dry gas is available and the small quantities vented through the controller pilot valves constitute no hazard or nuisance, it is often used instead of air with entire success. Needless to say, it must not be corrosive to the metals used in the controller construction.

Sturdier construction and better armoring of this tubing have made it so rugged that with anything like reasonable care it will last for the life of the instrument. When run for considerable distances it should be supported by small metal cleats and of course should not be unnecessarily kinked or subjected to repeated flexing or binding.

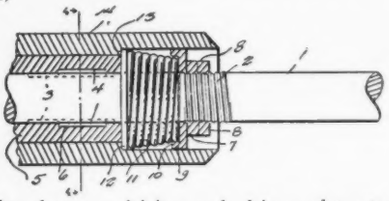
A vast majority of oil control bulb installations are made in separable sockets or wells. Steel, stainless steel, monel and other metals are used. The reason for the socket is obvious, both as a means of protecting the less easily replaced tube system and of permitting replacement and repair to be accomplished without waiting for a shut-down.

It goes without saying that the greatest care should be used to locate the sensitive element, the bulb or the socket for the bulb, at a point where it will be subjected to good circulation of the fluid whose temperature is being controlled. In fractionating tower installations the customary location is across the vapor line, although sometimes a 24-inch or 30-inch socket is inserted down through the tower top. In any case the sensitive portion should be as close as possible to the center of the vapor stream. Most oil installations are made with sockets, and a very worthwhile arrangement is to position the socket pointing downward or at least with a downward slant, so that mercury or oil can be introduced into the socket and thereby speed up the transmission of heat to the bulb. This simple kink will reduce the thermometric lag remarkably. Mercury can, of course, only be used when the bulb and the socket are of steel or monel construction. When other metals are involved, an oil which will not carbonize at the temperature can be used.

NEW PATENTS OF THE INDUSTRY

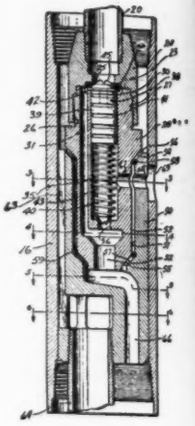


1,827,129. FLEXIBLE COUPLING. VILLOR P. WILLIAMS, Baltimore, Md., assignor, by mesne assignments, to Estelle P. Williams, Baltimore, Md. Filed Apr. 2, 1930. Serial No. 441,144. 6 Claims. (Cl. 64—89.)

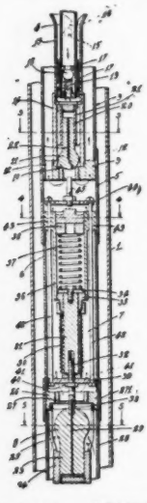


1. A coupling between driving and driven elements comprising a flexible connection between the elements for permitting some axial play therebetween, a pair of stop members on one element, a spring confined between the stop members, and a casing about the stop members and spring and provided with means for fixing the position of one stop member, and means carried by the said element for adjusting and limiting the movement of the other stop member, whereby the play of the latter element with respect to the first mentioned element is against the tension of the spring and limited thereby.

1,827,091. VALVE CONSTRUCTION FOR GAS PUMP. GLENN E. MAKINSTER, Los Angeles, Calif., assignor, by mesne assignments, to Jordan & Taylor, Inc., Los Angeles, Calif., a Corporation of California. Filed Nov. 19, 1928. Serial No. 320,372. 17 Claims. (Cl. 103—234.)

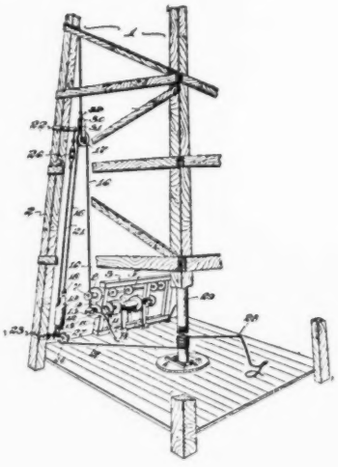


1. In a displacement pump for pumping wells, the combination of walls forming a displacement chamber adapted to be submerged in a liquid to be pumped, there being vent means communicating between said displacement chamber and the exterior of said walls, a piston slidable in a cylinder formed by said walls and operating, when the pressure pumping fluid exceeds a predetermined value, to admit said pressure fluid to said displacement chamber and to simultaneously close said vent means, and means for operating said piston when said pressure fluid is shut off to simultaneously close said pressure fluid passage and open said vent means.



1,827,066. GAS LIFT MEANS. MARK P. BURKE, Los Angeles, Calif. Filed June 18, 1928. Serial No. 286,124. 9 Claims. (Cl. 103—240.)

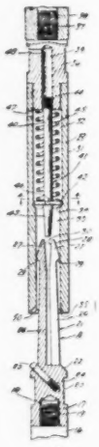
1. In an apparatus of the class described, the combination of a closed chamber adapted to be submerged in a column of liquid, means for admitting gas under pressure into the chamber, an outlet pipe extending from the chamber, means for admitting liquid from the column of liquid into the said chamber, and automatically fluid actuated means interposed between the said gas inlet, and liquid inlet means to actuate the liquid inlet means to a closed position after a predetermined quantity of liquid has been admitted into said chamber and open said gas inlet means.



1,826,760. CASING SPINNING APPARATUS FOR DRILLING RIGS. WALTER W. FOSTER, Wichita Falls, Tex. Filed Feb. 1, 1929. Serial No. 336,812. 3 Claims. (Cl. 255—35.)

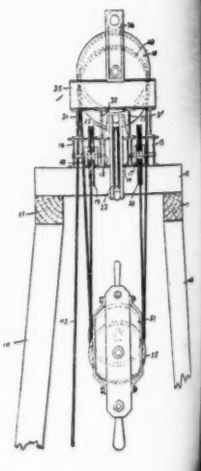
1. In an apparatus of the type set forth, pulling means, a line connected at one end to said pulling means to be pulled thereby and having its opposite end vertically disposed, a weight connected to said vertically disposed end, and a second line connected to the weight at one end and having its other end free and adapted to engage about and rotate a casing.

1,827,188. COUPLING FOR CONNECTING PUMP RODS AND PLUNGERS. LYSLE P. BURGESS, Los Angeles, Calif., assignor, by mesne assignments, to Emsco Derrick & Equipment Company, Los Angeles, Calif., a Corporation of California. Filed Aug. 27, 1925. Serial No. 52,831. 17 Claims. (Cl. 287—119.)



1. A coupling for automatically connecting a pump rod or the like to a pump plunger or the like, embodying a member carried by a plunger element, and a member carried by the pump rod, one of the members including a radially expansive stem, and the other member including a sleeve adapted to slide over the stem when the members are moved longitudinally together, an external shoulder on the stem, an internal shoulder on the sleeve, the stem being adapated to expand radially and engage its shoulder with the sleeve shoulder when the sleeve and stem are moved to have a predetermined amount of longitudinal overlap, the shoulder engagement being adapted to resist subsequent separative longitudinal movement of the sleeve and stem; and spring actuated means mounted in the sleeve and adapted to hold the stem in expanded condition when the shoulders are so engaged.

1,826,946. CROWN BLOCK. BURT STANLEY MINOR, San Pedro, Calif. Filed July 7, 1926. Serial No. 120,971. 6 Claims. (Cl. 254—190.)



1. The combination with a traveling block, of a crown block construction comprising two groups of cable sheaves disposed one above the other, the extreme face width of one group being approximately equal to the face width of the sheaves of the traveling block, the extreme face width of the other group of sheaves being approximately equal to the diametrical dimension of the sheaves of the traveling block, whereby the cable lines leading from the crown block sheaves to the sheaves of the traveling block will enter and leave the grooves of the traveling block sheaves at a minimum angle from the vertical.